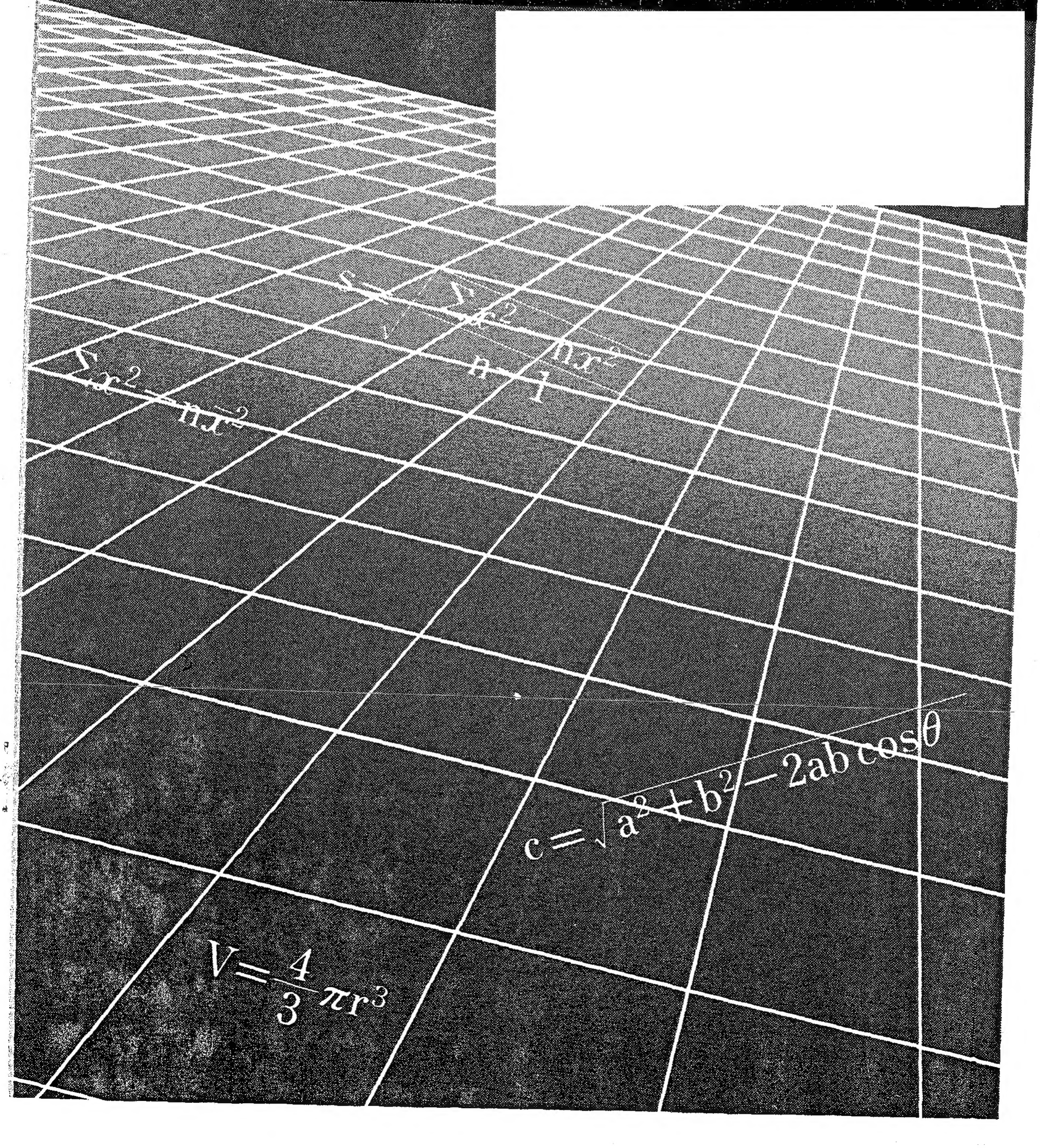
SHARP

CIENTIFIC CALCULATOR
VISSENSCHAFTLICHER RECHNER
ALCULATRICE SCIENTIFIQUE
ALCULADORA CIENTIFICA
ALCOLATRICE SCIENTIFICA

MODEL
MODELL
MODELE
MODELO
MODELLO

EL-5150

OPERATION MANUAL
BEDIENUNGSANLEITUNG
MODE D'EMPLOI
MANUAL DE MANEJO
MANUALE DI ISTRUZIONI



Contents

ENGLISH

NOTICE

- The contents of this manual are subject to change for improvements without notice.

- This calculator is provided with combinations of extremely sophisticated functions and has been shipped after thorough inspections including checks on the operations described in the Manual. Should you encounter any difficulties, contact your nearest SHARP distributor, dealer, or retailer. Your suggestions on the calculator are also invited. However, SHARP is not responsible for any consequences from the use of the calculator.

- SHARP is not responsible for any monetary loss or loss of profits from the use of any of the calculation examples contained in this manual or for any claims from a third party.

- SHARP is not responsible for any loss of, or damage to, the memory contents as a result of the repair or battery replacement of the calculator.

OPERATIONAL NOTES
(Handling Recommendations)

Because the liquid crystal display (LCD) of the EL-5150 is made of a liquid crystal hermetically sealed between two glass plates, adequate caution must be exercised in handling the calculator.

To ensure the trouble-free operation of the calculator, please observe the following points.

1. Do not carry the calculator in the back pocket of slacks or trousers.

2. Do not place the calculator in a location subject to direct sunlight, especially in a car with its window closed in hot climate. The calculator may be damaged due to high temperatures.

3. Do not place the calculator in a location exposed to high temperatures (e.g., near a heater). Also avoid locations subject to rapid temperature changes and excessive moisture or dust.

4. Do not drop or bump the calculator.

5. Do not use a cloth moistened with any volatile solvent or water to clean the calculator. Always use a soft, dry cloth.

If service should be required on this unit, use only a SHARP servicing dealer, SHARP approved service facility, or SHARP repair service where available.

CHAPTER 1
INTRODUCTION

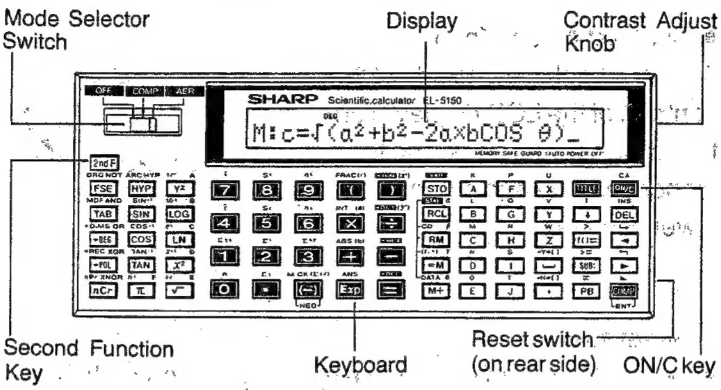
Chapter 1 of this manual introduces you to the SHARP EL-5150 Scientific Calculator, a new and powerful computing instrument, by providing you with a basic understanding of the calculator.

The EL-5150 allows direct entry of calculations and expressions (or formulas) as written. As you follow the detailed instructions and calculation examples in Chapters 2 and 3 of the manual, you will find that with this calculator you are not required to learn any machine or computer language, yet the unit provides you with formidable power in mathematical, scientific, engineering, and business calculations.

The EL-5150 features such unique functions as algebraic expression reserve function, conditional expression judgment and looping functions, and playback and answer memory functions. These important and useful functions are also detailed in Chapters 2 and 3, together with application examples.

Other items of supplemental information such as operating controls, error conditions, and so forth are included in Appendixes for ready reference.

Names of Components



- Mode selector switch

A 3-position slide switch used to turn on the power of the EL-5150 as well as to select either of the two operation modes of the unit: COMP and AER. (See Operation Modes on page 6 for details.)

- Keyboards

The keyboard consists of 66 keys arranged systematically in 14 columns by 4 or 5 rows, except that the 1st column (at the extreme left) has six keys. Of the many convenient keys, the two most frequently used keys are briefly introduced here to show you their functions and locations.

2nd Function key.............. A function change key used to designate the second function of another key. The second function of a key is printed in brown above the key.

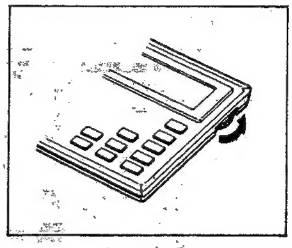
ON/Clear · Clear All key .... A clear/clear all key used to clear the contents of the display. This key is also used to turn on the power again when the calculator is automatically powered off. (See page 5 for details.)

• Display

A 24-digit liquid crystal display with each character formed in a pattern of 5×7 dots. (See Chapter 4 for details.)

• Contrast Adjust Knob

A control knob used to adjust the contrast of the LCD display. Turn this knob counterclockwise for higher contrast and clockwise for lower contrast.



• Reset switch

A switch used to retain or erase memory contents. When the EL-5150 is subjected to a large external noise or severe shock while in use, all the keys may become inoperative on rare occasions. Should such an abnormal condition occur in the calculator, take either of the following two actions:

(1) To retain memory contents

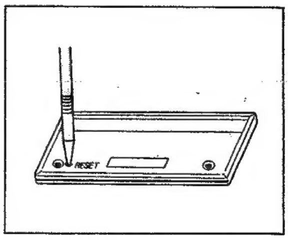
Set the Mode Selector switch to the COMP position and press the Reset switch, and the display will show the following.

Ø.

The calculator can now perform a calculation while retaining its memory contents.

NOTE:

When pressing the Reset switch, depress the switch with a ball-point pen as shown in the illustration. Avoid use of a sharp-pointed pencil or equivalent with an easy-to-break point.



(2) To erase memory contents

Set the Mode Selector switch to the AER position and press the Reset switch. Check to see if the display shows the following:

```
ALL  CLEAR  ?  →ENT
```

If not, press the Reset switch again. If yes, press the ENT (COMP) key to erase the memory contents of the calculator. You can now perform programming. Memory contents will not be cleared when any key other than ENT (COMP) is pressed.

NOTE:

If the memory contents have been changed due to large external noise or severe shock, the memory contents may have already been erased despite the reset operations described in (1) and (2) above.

Auto-Power Off Feature

If no key is pressed for about 10 minutes, the power automatically turns off to conserve battery power. The memory is retained. (The actual time may be shorter or longer than 10 minutes depending upon the operating temperature or battery condition) To resume operation, press the ON/C key.

Operation Modes

The EL-5150 operates in two basic modes: COMP, an abbreviation for Computation and AER, an abbreviation for Algebraic Expression Reserve. To permit the calculator to operate in either of the two modes, the 3-position Mode Selector switch at the upper left corner of the keyboard must be set to the appropriate position as described below.

OFF (left)	Turns off the power. Memory contents will be retained.
COMP (center)	Turns on the power and places the unit in the COMP mode.
AER (right)	Turns on the power and places the unit in the AER mode.

COMP Mode

The COMP mode allows the calculator to perform all calculations ranging from the four basic arithmetic functions to algebraic expressions programmed in the AER mode. In this mode, the calculator normally performs calculations in the decimal number system. The calculator has special calculation modes: BIN, OCT, and HEX modes for calculations of binary, octal, and hexadecimal numbers respectively, plus STAT mode for statistical calculations.

AER Mode

The AER mode allows you to program algebraic and other expressions into the calculator, that is, to store them in memory for later use in COMP mode. (See Chapter 3 for details on program execution.)

This mode also has a special mode called the VAR mode in which you can enter lower-case letters, numbers (reduced in size), and Greek letters (α, β, γ, and θ) as variables for the expressions to be programmed.

Fundamentals of Operation

Key Operation

The EL-5150 is provided with a wide variety of functions including scientific and algebraic expression reserve functions as well as four basic arithmetic (add, subtract, multiply, and divide) functions. Here, the procedural steps in performing basic calculations are briefly covered to warm you up before going into the details described in Chapters 2 and 3.

(1) Power ON

As mentioned earlier, you will find a three-position slide switch at the upper left corner of the keyboard. This switch serves as a mode selector. Slide the switch from the OFF position to either the COMP or AER position and your calculator will be powered.

(2) Operation Mode Selection

The EL-5150 operates in two modes: COMP mode that allows the calculator to perform calculations and AER mode that allows the unit to store algebraic expressions in memory. For the purpose of explanation, the unit is put in the COMP mode by setting the mode selector switch to the COMP position.

(COMP mode is set)

Display:

Ø.

NOTE:

When the unit is set in the COMP mode, message "COMP MODE" appears momentarily in the display and then "Ø." is displayed.

(3) Add, Subtract, Multiply, and Divide Functions

To perform any of the four basic functions with the EL-5150, enter the numeric data and press the algebraic keys ([+] , [−] , [×] , [÷] , [=]) in the same sequence as you would do with any other scientific calculators.

Example 1:

To calculate 123 + 654 =

Key in:

[1] [2] [3] [+]

1 2 3 + _

Key in:

[6] [5] [4]

1 2 3 + 6 5 4 _

Press:

[=]

7 7 7.

Example 2:

To calculate 2.4×2 =

Key in:

[2] [•] [4] [×] [2]

2. 4 × 2 _

Press:

[=]

4. 8

If you make an error in key sequence and an error message appears in the display, press the [ON/C] key and enter the data again in the correct sequence. If you key in the incorrect data, use the [◄] or [►] key to move the cursor over to the incorrect number or letter in the display and then enter the correct data. (See APPENDIX D for error messages.)

(4) Scientific functions

As an example of scientific functions, we will solve for the reciprocal of a number using the Reciprocal ([x^{-1}]) key.

Example:

To solve for $\frac{1}{8}$ = (or 8^{-1} =)

Key in:

[8] [2ndF] [x^{-1}] [=]

Ø. 125

NOTE:

[x^{-1}] is the second function of [x^2] and can be activated by pressing [2ndF] key, then [x^2] key.

Key Functions

- With the EL-5150, most of the keys have two functions, whereas some keys have three and some just one. The function printed on the key top is caused to occur when you press the key alone. The function printed in brown above the key is the second function of that key, and becomes effective only when the key is pressed following the function change key labeled "2nd F" as you have just done in the above calculation example.

NOTE:

The functions labeled "ENT" and "NEG" below the [COMP] and [(−)] keys respectively are not the second functions of these keys.

- Functions labeled " STAT, CD, (x, y), and DATA" in black at the left above the RCL, RM, ⇒M, and M+ keys respectively are those used for statistical calculations and are thus effective only in the STAT mode. (See page 54 for statistical calculation.) Functions labeled "α, β, γ, and θ" in black at the right above these keys are used for entry of characters as variables in the VAR mode.

- Functions labeled "**A**,**B**,**C**,**D**,**E**, and **F**" in black at the right above the Y^x, LOG, LN, x^2, $\sqrt{\ }$, and π keys respectively are those used for entry of hexadecimal numbers in the HEX mode.

- Functions labeled "NOT, AND, OR, XOR, and XNOR" in black at the right above the FSE, TAB, →DEG, →POL and nCr keys respectively are those used to perform the logical operations of binary, octal, and hexadecimal numbers in the respective number system modes.

NOTE:
Multiply command "X" and upper-and lower-case letters "X" are distinguished from one another by indicating them on the dispay as follows:

X	(letter)	→ X
X	(multiply)	→ ×
2ndF VAR X	(variable)	→ x

Conventions for Key Entry Descriptions

- In the following Chapters, key operations and key functions are described whenever possible as shown in the following examples:

key	Key operation	Designated function
SIN^{-1} / [SIN]	[2ndF] [SIN^{-1}]	SIN^{-1}
	[SIN]	SIN
$\sqrt[3]{\ }$ E / [$\sqrt{\ }$]	[E]	Hexadecimal number **E**
	[2ndF] [$\sqrt[3]{\ }$]	$\sqrt[3]{\ }$
	[$\sqrt{\ }$]	$\sqrt{\ }$
CD β / [RM]	[β]	Greek letter "β"
	[CD]	CD
	[RM]	RM

- All numeric keys for data entry are not enclosed in a box unlike other boxed keys indicating that they are the keys pressed:

[1] [2] [3] [•] [4] → 123.4 (decimal number)

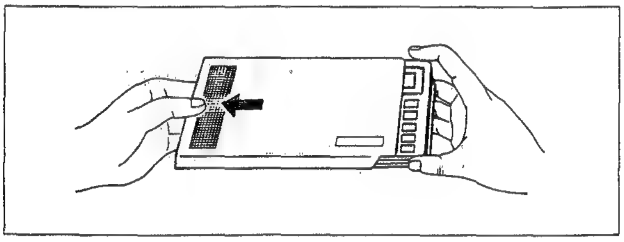
[2] [B] [C] → 2BC (hexadecimal number)

- The word "key in" or "press" before each key operation is omitted.

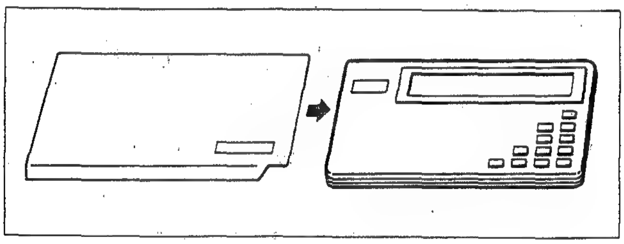
How to Use Protective Cover

The protective plastic cover with instruction labels attached to its inside is supplied as an accessory for protecting the calculator against shock. When you are not using the unit or carrying it in your briefcase, be sure to attach the protective cover to the unit.

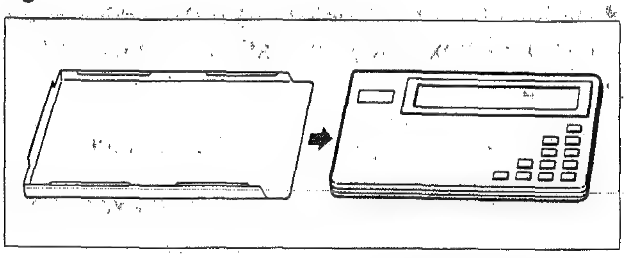
- Removing the cover



- Attaching the cover when the unit is not in use



- Attaching the cover while the unit is in use



CHAPTER 2
OPERATIONS IN COMP MODE

Before operating each calculation example in this chapter, make sure that the Mode Selector switch is in the COMP position and then press the ON/C key to clear the calculator. Unless otherwise stated, all the following calculation examples are to be performed in the floating decimal point system.
If any of the **FIX**, **SCI**, and **ENG** indicators is appearing in the display, press the FSE key consecutively until none of these indicators appears, indicating that your calculator's display is in the floating decimal point mode.

Addition, Subtraction, Multiplication, & Division

Examples shown here are the mixed calculations of the four basic functions.

NOTE:
This calculator uses algebraic logic. Calculations are not necessarily performed in the order entered. For example, multiplication is carried out before addition. Priority levels in calculation are detailed in APPENDIX E.

Example 1:

49.6 − 75.2 + 32=

[ON/C] 49.6 [−] 75.2 [+] 32 [=]

6.4

Example 2:

45 + 285 ÷ 3 =

45 [+] 285 [÷] 3 [=]

140.

Example 3:

(45 + 285) ÷ 3 =

[(] 45 [+] 285 [)] [÷] 3 [=]

110.

NOTE:
The parenthesis keys specify which group of numbers to calculate first whenever there is a choice. If you omitted parentheses, your answer would be 140 as in Example 2 because division takes precedence over addition. (See APPENDIX E for details on priority levels.)

Example 4:
$42\times(-5)+120=$

42 [×] [(−)] 5 [+] 120 [=]

−9 0.

NOTE:
When you enter a negative number, press [(−)] before the negative number.

Example 5:
$(5\times10^{3})\div(4\times10^{-3})=$

5 [Exp] 3 [÷] 4 [Exp] [(−)] 3 [=]

1 2 5 0 0 0 0.

NOTE:
[Exp] is used to enter the exponent part of a number.

Example 6:
$72\times(((56+23)\times2)-72\div4)=$

72 [(] [(] [(] 56 [+] 23 [)] [×] 2 [)]
①

[−] 72 [÷] 4 [=]
②

1 0 0 8 0.

NOTE:

1. As in ① above, the multiply key immediately before the open parenthesis may be omitted.
2. As in ② above, the closed parenthesis before the equals key may be omitted.
3. Plural parentheses may be entered in an expression with other calculation commands for more complicated arithmetic sequences, provided that the number of pending operations in the calculator does not exceed 16 and the number of pending values in the calculator does not exceed 8. (See APPENDIX E for details on pending operations.)

Scientific Functions

Scientific calculations are performed in the same manner as basic calculations. As you will note in the following examples, scientific funtions are entered as you would normally read them.

Trigonometric Functions

When you solve for any of the trigonometric and inverse trigonometric functions, you must first designate the unit of angle applicable to the function using the [2ndF] and [DRG] keys. As these two keys are pressed consecutively, the indications "DEG", "RAD", and "GRAD" appear alternately at the upper part of the display. Keep pressing [2ndF] [DRG] until the desired unit of angle is set on the display.

DEG: Degree [°]
RAD: Radian [RAD] $\quad 90[°] = \frac{\pi}{2}$ [RAD] = 100 [g]
GRAD: Grad [g]

NOTE:

The designated unit of angle will be retained in memory even when the power is turned off.
Therefore, you need not redesignate the angular unit each time the power is turned on.

Example 1:

SIN 63 =
Angular unit: DEG

[SIN] 63 [=]

DEG
Ø. 891ØØ6524

Example 2:

$\cos\frac{\pi}{4}=$

Angular unit: RAD

$\boxed{\text{COS}}$ $\boxed{(}$ $\boxed{\pi}$ $\boxed{\div}$ 4 $\boxed{)}$ $\boxed{=}$

RAD	Ø. 7Ø71Ø6781

NOTE:
To solve for the value for an expression as in $\cos\frac{\pi}{4}$, parenthesize the expression.

Example 3:

TAN150 =

Angular unit: GRAD

$\boxed{\text{TAN}}$ 150 $\boxed{=}$

GRAD	−1.

Inverse Trigonometric Functions

The calculation results of the respective inverse trigonometric functions are expressed within the following limits.

$\theta=\sin^{-1}x, \theta=\tan^{-1}x$	$\theta=\cos^{-1}x$
DEG $:-90\leqq\theta\leqq90$	DEG $:0\leqq\theta\leqq180$
RAD $:-\frac{\pi}{2}\leqq\theta\leqq\frac{\pi}{2}$	RAD $:0\leqq\theta\leqq\pi$
GRAD $:-100\leqq\theta\leqq100$	GRAD $:0\leqq\theta\leqq200$

In addition to the designation of the unit of angle using the [2ndF] and [DRG] keys, you must use the [2ndF] key for each calculation example here to designate the second function of another key.

Example 1:

COS^{-1} 0.5 =
Angular unit: DEG

[2ndF] [COS^{-1}] .5 [=]

DEG	6 Ø.

Example 2:

SIN^{-1} −1 =
Angular unit: RAD

[2ndF] [SIN^{-1}] [(−)] 1 [=]

RAD	−1. 57Ø796327

Example 3:

TAN^{-1} 1 =
Angular unit: GRAD

[2ndF] [TAN^{-1}] 1 [=]

GRAD	5 Ø.

Hyperbolic and Inverse Hyperbolic Functions
When using any of the hyperbolic and inverse hyperbolic functions, the "HYP" indicator will appear at the upper part of the display.

Example 1:

SINH 4 =

[HYP] [SIN] 4 [=]

27. 2899172

Example 2:

$(\text{COSH } 1.5 + \text{SINH } 1.5)^2 =$

[(] [HYP] [COS] 1.5 [+] [HYP] [SIN] 1.5 [)] [x^2] [=]

2Ø. Ø8553692

Example 3:

$\text{SINH}^{-1}\ 9 =$

[2ndF] [ARCHYP] [SIN] 9 [=]

2. 893443986

Example 4:

$\text{TANH}^{-1}\ \frac{5}{7} =$

[2ndF] [ARCHYP] [TAN] [(] 5 [÷] 7 [)] [=]

Ø. 895879735

Exponential Functions

Example 1:

$e^3 =$

[2ndF] [e^x] 3 [=]

2Ø. Ø8553692

Example 2:

$10^{1.7} =$

[2ndF] [10^x] 1.7 [=]

5 0. 1 1 8 7 2 3 3 6

Logarithmic Functions (Natural and Common Logarithms)

Example 1:

LN 20 =

[LN] 20 [=]

2. 9 9 5 7 3 2 2 7 4

Example 2:

LOG 50 =

[LOG] 50 [=]

1. 6 9 8 9 7 0 0 0 4

Squaring

Example:

$5^2 - 4^2 =$

5 [x^2] [−] 4 [x^2] [=]

9.

Reciprocals

Example:

$\frac{1}{8} =$

8 [2ndF] [x^{-1}] [=]

Ø. 125

Square Root and Cubic Root

Example 1:

$\sqrt{49} + \sqrt{64} =$

[$\sqrt{\ }$] 49 [+] [$\sqrt{\ }$] 64 [=]

15.

Example 2:

$\sqrt[3]{123 \times 6} =$

[2ndF] [$\sqrt[3]{\ }$] [(] 123 [×] 6 [)] [=]

9. Ø36885658

Power

Example 1:

$3^4 =$

3 [Y^x] 4 [=]

81.

Example 2:

$8^{-2}=$ (or $\frac{1}{8^2}=$)

8 $\boxed{Y^x}$ $\boxed{(-)}$ 2 $\boxed{=}$

Ø. Ø15625

Example 3:

$(12^3)^{\frac{1}{4}}=$ (or $\sqrt[4]{12^3}=$)

12 $\boxed{Y^x}$ 3 $\boxed{Y^x}$ 4 $\boxed{\text{2ndF}}$ $\boxed{x^{-1}}$ $\boxed{=}$

6. 447419591

Power Root

Example:

$\sqrt[4]{81}=$

4 $\boxed{\text{2ndF}}$ $\boxed{\sqrt[x]{\ }}$ 81 $\boxed{=}$

3.

Factorial

Example:

$6!=(6\times5\times4\times3\times2\times1=)$

6 $\boxed{\text{2ndF}}$ $\boxed{n!}$ $\boxed{=}$

72Ø.

Permutations

Formula:

$$nPr=\frac{n!}{(n-r)!}$$

Example:
From a group of 10 persons, you must decide how each combination of 3 persons should be lined up. What is the total number of ways the different groups of 3 can be arranged?

10 [2ndF] [nPr] 3 [=]

72Ø.

Combinations

Formula:

$$nCr=\frac{n!}{r!(n-r)!}$$

Example:
You must select 3 persons from a group of 10. How many different combinations of 3 persons can be formed?

10 [nCr] 3 [=]

12Ø.

Conversions of Coordinates

Two keys are used for conversions of coordinates.

[→POL] : Converts rectangular coordinates (x, y) into polar coordinates (r, θ)

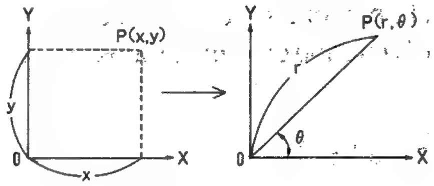
[→REC] : Converts polar coordinates into rectangular coordinates (x, y)

NOTE:
Because the calculator uses memory register Z to store the value of θ or y obtained from the conversion of coordinates, the contents of memory Z will be changed as the result of the conversion.

- Conversion of rectangular coordinates into polar coordinates ($x, y \rightarrow r, \theta$)

The value of θ is obtained within the following limits:

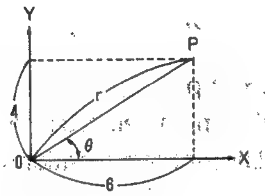
DEG :$0 \leqq |\theta| \leqq 180$
RAD :$0 \leqq |\theta| \leqq \pi$
GRAD:$0 \leqq |\theta| \leqq 200$



$$r=\sqrt{x^2+y^2},\ \theta=\mathrm{TAN}^{-1}\frac{y}{x}$$

Before you start the conversion, press the $\boxed{\text{2ndF}}$ and $\boxed{\text{DRG}}$ keys to designate the desired angular unit.

Example 1:
To solve for the values of polar coordinates (r, θ) with rectangular coordinates at point P ($x = 6, y = 4$)



Angular unit: DEG

6 $\boxed{\text{→POL}}$ 4 $\boxed{=}$

DEG	7. 2111Ø2551

(Answer for r)

$\boxed{\text{RCL}}$ $\boxed{\text{Z}}$ (or $\boxed{\text{Z}}$ $\boxed{=}$)

DEG	33. 69ØØ6753

(Answer for θ)

Example 2:
To solve for the magnitude and direction (phase) of a vector with $i = 12 + j9$

Angular unit: DEG

12 [→POL] 9 [=]

DEG 15.

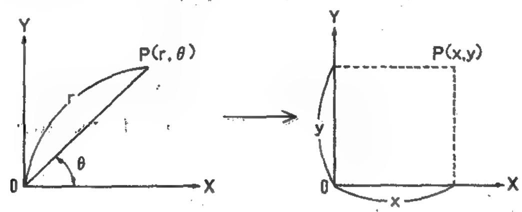
(Answer for magnitude)

[RCL] [Z] (or [Z] [=])

DEG 36.86989765

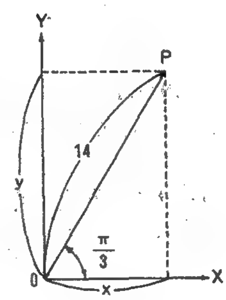
(Answer for direction)

- Conversion of polar coordinates into rectangular coordinates (r, $\theta \rightarrow$ x, y)



Expression:
$x = r\,COS\,\theta,\ y = r\,SIN\,\theta$

Example:
To solve for the values of rectangular coordinates (x, y) with polar coordinates at point P (r = 14, $\theta = \frac{\pi}{3}$)



Angular unit: RAD

14 [2ndF] [→REC] [(] [π] [÷] 3 [)] [=]

RAD 7.

(Answer for x)

[RCL] [Z] (or [Z] [=])

RAD 12. 12435565

(Answer for y)

Conversions of Angles

Two keys are used for conversions of angles.

[→DEG] : Converts an angle in the sexagesimal system (in degrees, minutes, and seconds) into its decimal equivalent (in degrees).

[→D.MS] : Converts an angle in the decimal system (in degrees) into its sexagesimal equivalent (in degrees, minutes, and seconds).

$\underbrace{\bigcirc\bigcirc}_{\text{degrees}}.\ \underbrace{\bigcirc\bigcirc}_{\text{minutes}}\ \underbrace{\bigcirc\bigcirc}_{\text{seconds}}\ \underbrace{\bigcirc\bigcirc}_{\text{fraction (decimal)}}$

Example 1:

To convert 12°39′18″ into its decimal equivalent

12.3918 [→DEG] [=]

12. 655

Example 2:

To convert 123.678° into its sexagesimal equivalent

123.678 [2ndF] [→D.MS] [=]

123. 4Ø4Ø8

(123° 40′ 40″ 8)

- Time calculations

The EL-5150 can also perform time calculations using the above angular conversion function.

Example 3:

$$\begin{array}{r} \text{3 hours 30 minutes 45 seconds} \\ +)\ \underline{\text{6 hours 45 minutes 36 seconds}} \\ \text{(total?)} \end{array}$$

(3.3045 →DEG + 6.4536 →DEG) 2ndF →D.MS =

10. 1621

(10 hours 16 minutes 21 seconds)

Other Functions

- Fraction (FRAC)

The FRAC function is used to display the fraction part of a number.

Example:

To solve for the decimal fraction part of the result of division 58 ÷ 8

2ndF FRAC (58 ÷ 8) =

0. 25

- Integer (INT)

The INT function is used to display of the integer part of a number.

Example:

To solve for the integer part of the result of division 58 ÷ 8

2ndF INT (58 ÷ 8) =

7.

- Absolute value (ABS)

The ABS function is used to determine the absolute value of a number.

Example:

To solve for the absolute value of log 0.75

2ndF ABS (LOG 0.75) =

0. 124938737

Playback Function

The playback function recalls the most recent expression. This is useful when you wish to confirm or correct your last calculation. In particular, this function is useful in finding the location of an error which may occur during the execution of a calculation, and thus increases efficiency in error processing.

Example 1:

To confirm the expression entered in memory

[ON/C] 5 [÷] 3 [=] (the display below is in the floating decimal point system)

```
1.6666666667
```

[PB]

```
5÷3=
```

Cursor blinks

Upon pressing the [PB] (Playback) key, a portion of your orginal input will appear in the display so that you may check or edit it.
If the expression is longer than the display, press [PB] again to obtain the remainder of your input. (Program correction and editing will be detailed in Chapter 3.)

Example 2:

To find the location of an error in calculation (in this example, 0 is erroneously used as divisor instead of 3)

5 [÷] 0 [+] 3 [=]

```
ERROR 2
```

Eroror code (see APPENDIX D)

[PB]

```
5÷0+3=
```

[◄]

```
5÷0+3=
```

3 [=]

```
4.666666667
```

The expression may also be changed using the [INS] key (to insert characters) and [DEL] key (to delete characters).

NOTE:

When a lengthy expression such as [(] 132 [×] [COS] 32 [+] 145 [×] [COS] 67 [)] [→POL] [(] 132 [×] [SIN] 32 [+] 145 [×] [SIN] 67 [=]
is entered in memory, the playback function causes the expression to be displayed by dividing it into sections, each of which falls within the 24-digit capacity of the LCD.

[PB]

```
(132×COS 32+145×COS 67)   →
```

[PB]

```
← →POL (132×SIN 32+145×   →
```

[PB]

```
← SIN 67=
```

[PB]

```
(132×COS 32+145×COS 67)   →
```

In the above example, the "←" indicator indicates that the contents of the display exist at the left of the number or data now being displayed. Likewise, the "→" indicator indicates that the number or data yet to be displayed exists at the right of the screen.

Answer Memory Function

Calculation results obtained with any of the operation execution keys ([=] , [M+] , [2ndF] [M+] , [⇒M] , [STO] [A] ~ [STO] [Z] , [→BIN] , [→OCT] , [→HEX] , [→DEC]) are stored in the answer memory. The value currently held in the answer memory (i.e., the result of the last computation) can be inserted into any position of the next algebraic expression by using the [ANS] key.

Example:

To calculate 12×5 ÷ 6.25 + 24×3 ÷ 6.25 = where 6.25 is the result of division 50 ÷ 8 = previously perfomed

[ON/C] 50 [÷] 8 [=]

```
6. 25
```

(automatically stored in memory)

12 [×] 5 [÷] [2ndF] [ANS]

```
12×5÷6. 25_
```

Recalled from answer memory

[+] 24 [×] 3 [÷] [2ndF] [ANS]

```
12×5÷6. 25+24×3÷6. 25_
```

Recalled from answer memory

[=]

```
21. 12
```

- While the value of the answer memory may be recalled as many times as required, it will be updated whenever an operation is executed with any of the operation execution keys. If an error exists in the result of a calculation, the value of the answer memory will remain unchanged. It will

also be updated when a program stored in the AER mode is executed.

- The contents of the answer memory will not be cleared by ON/C or 2ndF CA key operation or by power off operation.

Continuous Calculation & Modify Functions

Continuous Calculation Function

Like the answer memory function, the continuous calculation function allows you to use the result of the calculation last performed for the calculation to be next performed.

Example:

To solve for 3 + 4 = and then multiply the calculation result by 5.

[ON/C] 3 [+] 4 [=]

7.

[×] 5

7. × 5 _

(multiply command is input following the result of addition)

[=]

35.

NOTE:

The difference of this function from the answer memory function is that the result of the last calculation can be used only at the beginning of the next calculation.

Modify Function

The modify function causes the internal result of a calculation stored in memory when used in subsequent calculations, to be in agreement with the format of the result of the calculation in the display.
With the EL-5150, the result of a calculation is obtained to the accuracy of up to 12 digits for mantissa, while all the internally executed calculations are in the exponential form ($A \times 10^B$). The results of all the internal calculations are displayed on the LCD after being converted into the form designated by the display system (FIX, SCI, or ENG) and the number of decimal positions to be fixed (TAB). So, the use of this modify function allows you to use the calculation result in the display without change, for the next calculation to be performed. This function is very useful when you must perform calculations with the significant digits of a number taken into account as in testing or processing the results of experiments.

Example:

To solve for the result of 5 ÷ 9 = and then multiply the calculation result by 9

[FSE] (to display the FIX indicator)

[TAB] 1 (to fix the number of decimal positions to 1)

- Normal calculation

5 [÷] 9 [=]

FIX	Ø. 6

[×]

5. 6 E − Ø 1 × _	FIX

result of internal calculation

9 [=]

FIX 5. 0

NOTE:
In a continuous calculation like this example, the value in the display is not used for the calculation. Instead, the value stored in memory is used.

- Calculation with modify function

5 [÷] 9 [=] [2ndF] [MDF]

FIX 0. 6

[×]

FIX 0. 6×_

9 [=]

FIX 5. 4

Memory Calculations

The EL-5150 has 26 memories; one used as an independently accessible memory or store memory and 25 as store memories.

Independently Accessible Memory (M)

- How to use memory

Data movement in and out of the memory is effected by the following three memory control keys:

[⇒M] : Stores the result of a calculation in memory.
[RM] : Recalls the memory contents.
[M+] : Adds the results of a calculation to the memory contents.
[2ndF] [M+] : Subtracts the results of a calculation from the memory contents.

- Application examples of memory

Before you start a memory calculation, you must press either the [ON/C] and [⇒M] keys to clear the memory contents or the [⇒M] key to enter the initial data in the memory.

Example 1:

[ON/C] [⇒M] [FSE] (press until FIX, SCI, and ENG indicators disappear)

Ø.

(Memory clear)

$$
\begin{array}{rl}
23 + 45 + 78 = & \ldots (1) \\
-52 - 31 + 43 = & \ldots (2) \\
+)\ 64 + 73 - 12 = & \ldots (3) \\
\hline
\text{(total)} & \ldots (4)
\end{array}
$$

23 [+] 45 [+] 78 [M+]

146.

Answer for (1)

[(−)] 52 [−] 31 [+] 43 [M+]

−4 0.

Answer for (2)

64 [+] 73 [−] 12 [M+]

125.

Answer for (3)

[RM]

231.

Total (4)

Example 2:

$$\begin{array}{rl} 24 \times 13 = & \ldots (1) \\ +)\ 56 \div 7 = & \ldots (2) \\ -)\ 32 \times 4 = & \ldots (3) \\ \hline \text{(total)} & \ldots (4) \end{array}$$

24 [×] 13 [⇒M]

312.

Answer for (1)

56 [÷] 7 [M+]

8.

Answer for (2)

32 [×] 4 [2ndF] [M+]

128.

Answer for (3)

[RM]

192.

Total (4)

Example 3:

$24 \div \underline{(7 \times 3)} = \ldots (1)$

$\underline{(7 \times 3)} \times 5 = \ldots (2)$

7 [×] 3 [⇒M]

21.

24 [÷] [RM] [=]

1.142857143

Answer for (1)

[RM] [×] 5 [=]

105.

Answer for (2)

In this example, the result of multiplication 7×3 in calculation (1) is first stored in memory and is then recalled to use it as a constant for calculations (1) and (2).

NOTE:

The equals key need not be pressed before [⇒M], [M+], and [2ndF] [M+] as these keys also function as the equals key.

Store Memories

- How to use memories

Data movement in and out of each of the 26 store memories is effected by the following two memory control keys and 26 memory designation keys [A] through [Z].

[STO] : Clears the contents of the designated memory and stores the number in the display or the result of a calculation in the memory.

[RCL] : Functions the same as [RM] key.

- Application example of store memories

Example:

To solve for $C=\frac{AB}{(A+B)}$ with $A=\frac{(12+6)}{3}$ and $B=\frac{6}{(12-8)}$.

[(] 12 [+] 6 [)] [÷] 3 [STO] [A]

6.

Answer for (A)

6 [÷] [(] 12 [−] 8 [)] [STO] [B]

1. 5

Answer for (B)

AB [÷] [(] A [+] B [)] [=]

1. 2

Answer for (C)

NOTE:
Multiply command "X" may be omitted for multiplication between store memories (e.g., A×B) or for multiplication when a store memory is a multiplier (e.g., 3×A, 5×B).

- Use of store memories in expressions

With the EL-5150, the initial capacity of each memory to

store the result of a calculation is 12 digits max. for mantissa and 2 digits max. for exponent.
Any of the [A] through [Z] keys may be entered in an expression to use the contents of the designated memory in the expression. Any of the [A] through [Z] keys preceded by the [RCL] key may also be used to display the contents of the designated memory and write them into the expression for calculation.

Example:

To store the result of division 4 ÷ 3 into memory A and then perform the following calculations.

4 [÷] 3 [STO] [A]

```
1. 3333333333
```

① To use an expression written directly with [A] key.

[FSE] (to display FIX indicator)

[TAB] 2 (to designate the fraction part as 2 digits)

2 [A] [×] 3 [=]

```
FIX            8. ØØ
```

② To use an expression written with [RCL] and [A] keys.

2 [×] [RCL] [A] [×] 3 [=]

```
FIX            7. 98
```

In the example ① above, all the contents of memory A (12-digit mantissa and 2-digit exponent) are used, whereas in the example ②, only the internal digits of memory A specified by FIX, TAB = 2 are used for calculation.

NOTE:

1. Store memory M shares the same memory area as the independently accessible memory.
2. The result of a calculation cannot be automatically added to or subtracted from memories A through Z except M. A key sequence such as the one shown below would have to be used if the calculation result 5 is to be added to or subtracted from, for example, memory A:
   5 + [A] [STO] [A]
3. Store memory Z is used to store the results of calculations such as conversions of coordinates, [→POL], and [→REC].
4. Memories A through T can also be used in the STAT mode. Memories U through Z are used to store the statistics.
5. Remember that [RCL] does not carry all internal digits into a calculation if [TAB] is used (see the last example). To retain internal digits, enter the letter (memory designation key) without [RCL].

Binary, Octal, & Hexadecimal Number Calculations

The EL-5150 can perform conversions between any two of decimal, binary, octal, and hexadecimal numbers, and also perform four basic arithmetic operations on numbers expressed in these number systems. Decimal fractions are only possible in the DEC mode.

Number System Modes

To perform conversions between any two of decimal, binary, octal, and hexadecimal numbers, the calculator must be set in one of the following number system modes as applicable, with the Mode Selector switch in the COMP position.

[2ndF] [→BIN] : Binary Number System (BIN) Mode.

- Displays 16-digit binary numbers.
- Converts the number in the display into its binary equivalent. When these two keys are pressed, the BIN indicator appears at the upper part of the display.
- If an expression is in the display, the calculator performs the calculation of the expression and converts the calculation result into a binary number.
- In this mode, only [0] and [1] keys can be used. The other number keys and decimal point key thus become inoperative.

[2ndF] [→OCT] : Octal Number System (OCT) Mode

- Displays 10-digit octal numbers.
- Converts the number in the display into its octal equivalent. When these two keys are pressed, the OCT indicator appears at the upper part of the display.
- If an expression is in the display, the calculator performs the calculation of the expression and converts the calculation

result into an octal number.

● In this mode, only [0] through [7] keys can be used. The other number keys and decimal point key thus become inoperative.

[2ndF] [→HEX] : Hexadecimal Number System (HEX) Mode

● Displays 10-digit hexadecimal numbers.

● Converts the number in the display into its hexadecimal equivalent. When these two keys are pressed, the **HEX** indicator appears at the upper part of the display.

● If an expression is in the display, the calculator performs the calculation of the expression and converts the calculation result in a hexadecimal number.

● In this mode, numeral keys [0] through [9] and hexadecimal number keys [A] through [F] ([Y^x], [LOG], [LN], [x^2], [$\sqrt{\ }$], [π]) can be used. The decimal point key alone thus becomes inoperative.

[2ndF] [→DEC] : Decimal Number System (DEC) Mode

● Converts the number in the display into its decimal equivalent. When these two keys are pressed, no decimal number system indicator appears in the display. Since the calculator normally uses this number system, the absence of any number system mode means that the unit is in the decimal number system mode.

● If an expression is in the display, the calculator performs the calculation of the expression and converts the calculation result into a decimal number.

● In this mode, numeral keys [0] through [9] are used to perform four basic arithmetic operations and scientific calculations.

Cross-reference table for four basic notations

Decimal	Binary	Octal	Hexadecimal
0	0	0	0
1	1	1	1
2	10	2	2
3	11	3	3
4	100	4	4
5	101	5	5
6	110	6	6
7	111	7	7
8	1000	10	8
9	1001	11	9
10	1010	12	A
11	1011	13	B
12	1100	14	C
13	1101	15	D
14	1110	16	E
15	1111	17	F
16	10000	20	10
17	10001	21	11
18	10010	22	12
19	10011	23	13
20	10100	24	14
:	:	:	:

Conversions of Binary, Octal, Decimal, & Hexadecimal Numbers

Example 1:

To convert decimal number 19 into its binary equivalent (10011 from cross-reference table)

[ON/C] [2ndF] [→DEC] 19 (Decimal number)

```
1 9_
```

[2ndF] [→BIN] (Dec to Bin)

```
                    BIN
Ø Ø Ø Ø Ø Ø Ø Ø Ø Ø Ø 1 Ø Ø 1 1
```

Example 2:

To convert hexadecimal number 2BC into its decimal equivalent.

[ON/C] [2ndF] [→HEX] 2 B C (Hexadecimal number)

HEX
2 B C_

NOTE:

Use the hexadecimal number keys [Y^x], [LOG], [LN], [x^2], [√], and [π] to enter A, B, C, D, E, and F in the HEX mode.

[2ndF] [→DEC] (Hex to Dec)

7 Ø Ø.

Example 3:

To convert octal number 52 into its hexadecimal equivalent

[2ndF] [→OCT] 52 (octal number)

OCT
5 2_

[2ndF] [→HEX] (Oct to Hex)

HEX
Ø Ø Ø Ø Ø Ø Ø Ø 2 A

Example 4:

To convert binary number 101111 into its decimal, hexadecimal, and octal equivalents respectively

[2ndF] [→BIN] 101111 (Binary number)

BIN
1 Ø 1 1 1 1_

[2ndF] [→DEC] (Bin to Dec)

4 7.

[2ndF] [→HEX] (Bin to Hex)

HEX
Ø Ø Ø Ø Ø Ø Ø Ø 2 F

[2ndF] [→OCT] (Bin to Oct)

OCT
Ø Ø Ø Ø Ø Ø Ø Ø 5 7

Example 5:

To convert a decimal number with a fraction part into its binary, octal, or hexadecimal equivalent

[2ndF] [→DEC] 12.34 [2ndF] [→HEX]

HEX
Ø Ø Ø Ø Ø Ø Ø Ø Ø C

As shown in the above example, the fraction part (0.34) is truncated and only the integer part (12) is converted into its hexadecimal equivalent.

Binary, Octal, & Hexadecimal Number Calculations

With the EL-5150, four basic arithmetic operations (add, subtract, multiply, and divide) and memory calculations can be performed in the BIN, OCT, and HEX modes just the same as in the normal DEC mode. (In other than the DEC mode, scientific functions cannot be perfomed.)

- BIN mode

Example 1

1011 + 1110 =

[ON/C] [2ndF] [→BIN] 1011 [+] 1110 [=]

BIN
Ø Ø Ø Ø Ø Ø Ø Ø Ø Ø Ø 1 1 Ø Ø 1

Example 2:

(1010 − 100)×11 =

[( ] 1010 [−] 100 [ )] [×] 11 [=]

BIN
ØØØØØØØØØØØ1ØØ1Ø

● OCT mode

Example 1:

5 + 7 =

[ON/C] [2ndF] [→OCT] 5 [+] 7 [=]

OCT
ØØØØØØØØ14

Example 2:

32 ÷ 2 =

32 [÷] 2 [=]

OCT
ØØØØØØØØ15

● HEX mode

Example 1:

2FF − 25 =

[ON/C] [2ndF] [→HEX] 2FF [−] 25 [=]

HEX
ØØØØØØØ2DA

Example 2:

(2000 − 1FC) ÷ 2 =

[( ] 2000 [−] 1FC [ )] [÷] 2 [=]

HEX
ØØØØØØØFØ2

- Mixed calculations

Example 1:

To add decimal number 512 to hexadecimal number 1FFF and convert the calculation result into a binary number

[ON/C] [2ndF] [→DEC] 512 [2ndF] [→HEX] [+] 1FFF [2ndF] [→BIN]

BIN 0 0 1 0 0 0 0 1 1 1 1 1 1 1 1 1

Example 2:

2FEC − 2C9E = ... (1)
+) 2000 − 1901 = ... (2)
Total (decimal number) ... (3)

[ON/C] [⇒M] [2ndF] [→HEX] 2FEC [−] 2C9E [M+]

HEX 0 0 0 0 0 0 0 3 4 E

Answer for (1)

2000 [−] 1901 [M+]

HEX 0 0 0 0 0 0 0 6 F F

Answer for (2)

[RM] [2ndF] [→DEC]

2 6 3 7.

Answer for (3)

NOTE:

In binary, octal, or hexadecimal number calculations, if the result or intermediate result of a calculation turns to be a number with a fraction part, the result is displayed with its fraction part truncated.

Example:

[2ndF] [→OCT] 5 [÷] 2 [=]

OCT 0 0 0 0 0 0 0 0 0 2

In the BIN, OCT, or HEX mode, a negative number is displayed as a complement corresponding to the designated number system.

Example:

[2ndF] [→DEC] [(−)] 1

− 1 _

[2ndF] [→BIN]

BIN 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1

(two's complement)

[2ndF] [→OCT]

OCT 7 7 7 7 7 7 7 7 7 7

(eight's complement)

[2ndF] [→HEX]

HEX F F F F F F F F F F

(16's complement)

In the BIN, OCT, or HEX mode, a negative number is entered using the [NEG] ([(−)]) key.

Example:

To enter negative hexadecimal number 2

[2ndF] [→HEX] [NEG] 2

N E G 2 _ HEX

[=]

HEX F F F F F F F F F E

Logical Operations

The EL-5150 can perform logical AND, OR, XOR (exclusive OR), XNOR (exclusive NOR), and NOT operations on binary, octal, and hexadecimal numbers.
To enter logical operators, NOT, AND, OR, XOR, and XNOR, use the [FSE], [TAB], [→DEG], [→POL], and [nCr] keys, respectively. The function printed at the right above each of these keys will be entered.

The truth tables of the logical operations are as shown below.

A	B	A AND B	A OR B	A XOR B	A XNOR B
0	0	0	0	0	1
1	0	0	1	1	0
0	1	0	1	1	0
1	1	1	1	0	1

A	NOT A
0	1
1	0

Example 1:
AND operation of binary numbers 1101 and 111

[ON/C] [2ndF] [→BIN] 1101 [AND] 111 [=]

BIN
ØØØØØØØØØØØØØ1Ø1

Example 2:

OR operation of hexadecimal numbers 5B and F3

[ON/C] [2ndF] [→HEX] 5B [OR] F3 [=]

HEX
ØØØØØØØØFB

Example 3:

NOT operation of binary number 101011

[ON/C] [2ndF] [→BIN] [NOT] 101011 [=]

BIN
1111111111Ø1Ø1ØØ

Example 4:

Exclusive-OR operation of octal numbers 26 and 54

[ON/C] [2ndF] [→OCT] 26 [XOR] 54 [=]

OCT
ØØØØØØØØ72

Example 5:

Exclusive-NOR operation of hexadecimal numbers A5 and 2F

[ON/C] [2ndF] [→HEX] A5 [XNOR] 2F [=]

HEX
FFFFFFFF75

Example 6:

OR operation of hexadecimal number 8E and binary number 11101

[ON/C] [2ndF] [→HEX] 8E [2ndF] [→BIN] [OR] 11101 [=]

BIN
ØØØØØØØØ1ØØ11111

Example 7:

AND operation of hexadecimal number F5 and the result of OR operation of hexadecimal numbers 84 and 7E

[ON/C] [2ndF] [→HEX] [(] 84 [OR] 7E [)] [AND] F5 [=]

HEX 0 0 0 0 0 0 0 0 F 4

Statistical Calculations

Statistical Calculation (STAT) Mode

- Before performing a statistical calculation, you must place the calculator in the STAT mode. To do so, press the [2ndF] and [STAT] keys with the Mode Selector switch in the COMP position, and the STAT indicator will appear at the upper part of the display.
To release the calculator from the STAT mode, press the [2ndF] and [STAT] keys a second time.

- Remember that in the STAT mode, those keys not used for statistical calculations become inoperative. Examples of such keys are: [RM] , [⇒M] , [M+] , [2ndF] [M+] , [U] – [Z] , [COMP] , [TITLE] , [↓] , [↑] . Those keys used in the AER mode are also inoperative. In the STAT mode, binary, octal, and hexadecimal number calculations and conversions of coordinates cannot be effected.

- The results of statistical calculations cannot be cleared with the [ON/C] . Use the [2ndF] and [CA] keys to clear the statistics stored in memories U through Z before you start another statistical calculation.

- Even after the results of a statistical calculation have been obtained, additional information can be entered and the statistical calculation can be performed continuously on additional data entry.

- The following statistics obtained from a statistical calculation are stored in memories U through Z and are retained in memory even after the calculator is released from the STAT mode.

Memory	Z	Y	X	W	V	U
Contents	n	Σx	Σx^2	Σxy	Σy	Σy^2

- Memories A through T may also be used in the STAT mode and their contents will not be affected by any statistical calculations.

Single-variable Statistical Calculation

- Statistics obtainable from calculation

(1) n : Number of samples
(2) Σx : Sum total of samples
(3) Σx^2: Sum of squares of samples
(4) $\bar{x}$: Mean value of samples

$$\bar{x}=\frac{\Sigma x}{n}$$

(5) sx : Standard deviation with population parameter taken as "n-1".

$$sx=\sqrt{\frac{\Sigma x^2-n\bar{x}^2}{n-1}}$$

(Used to estimate the standard deviation of a population from the sample data extracted from that population.)

(6) σx : Standard deviation with population parameter taken as "n".

$$\sigma x=\sqrt{\frac{\Sigma x^2-n\bar{x}^2}{n}}$$

(Used when all populations are taken as sample data or when finding the standard deviation of a population with samples taken as that population.)

- Data input for calculation

Data for single-variable statistic calculations are entered by the following key operations:
(1) Data $\boxed{\text{DATA}}$ (used to enter data one by one)
(2) Data $\boxed{\times}$ Frequency $\boxed{\text{DATA}}$ (used to enter two or more of the same data)

Data can be entered in the form of an algebraic expression. However, it must be parenthesized when the "+", "−", "×" or "÷" command is used.

Examples:
(5 + 4×3) [DATA] ·················· Frequency of data is 1.
(SIN3 + LN2)×5 [DATA] ······· Frequency of data is 5.

In the above examples, if the expression was not parenthesized, 5+ and SIN3+ would be ignored, and the same results would be returned as in key operations 4×3 [DATA] and LN2×5 [DATA] .
Frequency of data entered in the form of an expression must also be parenthesized.

Example:

10 [×] [(] 3 [+] 2 [)] [DATA]

↑ must be parenthesized.

- **Calculation**

Example:
To solve for the mean value and standard deviation of the marks in an examination of randomly selected 35 students shown in the table below.

Data No.	Marks in exam	No. of students	Data No.	Marks in exam	No. of students
1	30	1	5	70	8
2	40	1	6	80	9
3	50	4	7	90	5
4	60	5	8	100	2

[2ndF] [STAT] (STAT mode is set)
[2ndF] [CA]

STAT 0.

(STAT indicator lights)

- Data entries

30 [DATA] 40 [DATA]

STAT 2.

(Number of samples is displayed)

50 [×] 4 [DATA] 60 [×] 5 [DATA]

STAT 11.

70 [×] 8 [DATA] 80 [×] 9 [DATA]

STAT 28.

90 [×] 5 [DATA] 100 [×] 2 [DATA]

STAT 35.

- Mean value

[2ndF] [$\bar{x}$]

STAT 71.42857143

- Standard deviation

[2ndF] [Sx]

STAT 16.47508942

[2ndF] [σx]

STAT 16.23802542

- Number of samples

[2ndF] [n]

STAT 35.

- Sum total of samples

[2ndF] [Σx]

STAT 2500.

- Sum of squares of samples

[2ndF] [Σx^2]

STAT 187800.

[2ndF] [STAT] (STAT mode is released)

0.

(STAT indicator goes off)

NOTE:

1. After all the data have been entered, statistics such as mean value, standard deviation, etc. may be obtained in any desired order.
2. After a mean value, standard deviation, or any other statistic has been obtained as an intermediate result, more data can be entered and statistical calculations can be performed continuously on additional data entry.
3. The [DATA] key may be pressed consecutively to enter two or more of the same data instead of key operation; [X] Frequency [DATA] .

• Data entry correction

If an erroneous data has been entered, the incorrect entry can be corrected using the [CD] key.

Example:
To correct the marks of data No. 3 erroneously entered as 55 instead of 50 in the above example

[2ndF] [STAT] [2ndF] [CA]

STAT 0.

- Data entries

30 [DATA]

STAT 1.

40 [DATA]

STAT 2.

55 [×] 4 [DATA]

STAT 6.

(Incorrect data is input)

- Data correction

55 [×] 4 [CD]

STAT 2.

(Incorrect data is cleared)

50 [×] 4 [DATA]

STAT 6.

(Correct data is input)

60 [×] 5 [DATA]

STAT 11.

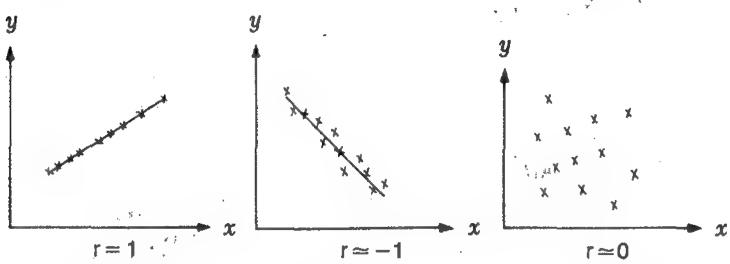
NOTE:
An erroneous data entry before pressing the [DATA] key can be cleared by the [ON/C] key. The correct data may then be entered.

Two-variable Statistical Calculation

● Statistics obtainable from calculation

Statistics for both x and y such as n, Σx, $\bar{x}$, Σx^2, sx, σx, and Σy, $\bar{y}$, Σy^2, sy, σy are the same as those for x in single-variable statistics, except that samples should be identified as x and y respectively. In addition, Σxy (the sum of the product of samples x and y) is obtained in this calculation.

In Linear Regression there are three important values; r, a, and b. The correlation coefficient r shows the quantitative relationship between two variables x and y for a particular sample. The value of r is between −1 and 1. If r equals −1 or 1, all points on the correlation diagram are on a line. The further the value of r is from −1 or 1, the less the points are massing about the line. The closer the value of r to 0, the less reliable is the correlation. If r is more than 0, it shows a positive correlation (y is in proportion to x) and if r is less than 0, it is a negative correlation (y is in inverse proportion to x).



The equation for the straight line is y = a + bx. The point at which the line crosses the y axis is a. The slope is b.

r : Correlation coefficient

$$r = \frac{Sxy}{\sqrt{Sxx \cdot Syy}}$$

a : $a = \bar{y} - b\bar{x}$ } Coefficient of linear regression equation $y = a + bx$

b : $b = \frac{Sxy}{Sxx}$

x′ : Estimated value (the value of x is estimated from that of y.) $x' = \frac{y - a}{b}$

y′ : Estimated value (the value of y is estimated from that of x.) $y' = a + bx$

$$\left[\begin{array}{l} Sxx=\Sigma x^2-\frac{(\Sigma x)^2}{n} \\ Syy=\Sigma y^2-\frac{(\Sigma y)^2}{n} \\ Sxy=\Sigma xy-\frac{\Sigma x\cdot \Sigma y}{n} \end{array}\right]$$

- **Data input for calculation**

Data for two-variable statistic calculations are entered by the following operations.

(1) Data "x" $\boxed{(x,y)}$ Data "y" $\boxed{\text{DATA}}$ (used to enter data one by one)

(2) Data " x" $\boxed{(x,y)}$ Data "y" $\boxed{\times}$ Frequency $\boxed{\text{DATA}}$ (used to enter two or more of the same data)

Example:

85 $\boxed{(x,y)}$ 79 $\boxed{\text{DATA}}$	Frequency of data is 1.
51 $\boxed{(x,y)}$ 73×5 $\boxed{\text{DATA}}$	Frequency of data is 5.

- **Calculation**

Example:
The following table shows the marks in Math and English of six students respectively. From this data, solve for the coefficients a and b of linear regression y = a + bx and correlation coefficient r. Then extimate the mark in English of a student who would get 90 marks for Math and the mark in Math of a student who would get 80 marks for English.

Student No. n	Mark in Math. x	Mark in English y
1	82	79
2	53	50
3	61	87
4	74	96
5	51	73
6	51	73

2ndF STAT 2ndF CA

82 (x,y) 79 DATA 53 (x,y) 50 DATA

61 (x,y) 87 DATA 74 (x,y) 96 DATA

51 (x,y) 73 × 2 DATA

STAT 6.

2ndF (a)

STAT 34.26190476

2ndF (b)

STAT 0.678571429

2ndF (r)

STAT 0.571587901

(This is a moderately reliable correlation.)

90 2ndF (y')

STAT 95.33333333

(Estimated mark in English)

80 2ndF (x')

STAT 67.40350877

(Estimated mark in Math)

CHAPTER 3
OPERATIONS IN AER MODE

The EL-5150 is provided with a mode called the "Algebraic Expression Reserve (AER)", which is convenient for repetitive calculations. This mode allows you to preprogram calculation procedures (i.e., algebraic expressions) into the calculator in the AER mode so that the calculator may automatically execute calculations on numbers (variables) which you will enter in the COMP mode. The calculator has a programming capacity of 1,454 steps (or 1,454 bytes) for storing programs consisting mainly of algegraic expressions and mathematical formulas. In addition, the calculator can perform conditional expression judgment, looping, and subroutine functions.

How to Use Algebraic Expression Reserve

Configuration of AER

An algebraic expression (or a program) consists of a title and a main routine with or without one or more subroutines.

- Configuration

Programming sequence →

Title number ↓

01: Title Main Sub1... 9,0
02: Title Main Sub1... 9,0
⋮
99: Title Main Sub1... 9,0

- Input message

Input of title name

```
Ø1 : TITLE ?
```

Input of main routine

```
M : _
```

Input of subroutine(s)

```
1 : _
```

```
2 : _
```

⋮

```
0 : _
```

(1) Title

To store a program, first type in the program title name:

- When you slide the MODE Selector switch to the AER position, a message: "Ø1:TITLE?" will appear in the display to prompt you to enter the title of your program. A title name may not necessarily be entered. But it's better to have one for quick, easy retrieval of the program you want to use later. You may program a maximum of 99 algebraic expressions within the memory capacity of the calculator. A 2-digit title number (01 - 99) will be displayed to the left of the "TITLE?" message.

- Up to 21 characters may be used for a single title. Title characters exceeding 21 characters will be ignored. (Some keys are not usable for program title entry.)

- Pressing the [ENT] key following the entry of title characters causes the program title to be stored in memory. If no program title is needed, press the [ENT] key alone.

(2) Main routine

- When you press the [ENT] key to store the program title, "M:_" will appear in the display. This indicator "M" informs you that you are going to store a main routine. (The first program line immediately after a program title is automatically assigned to a main routine.)

(3) Subroutine(s)

- In a series of calculation procedures, if you have an expression to be used over and over again, it is advisable to write the expression as a subroutine for execution as the occasion calls for. In this way, you can simplify the calculation procedures.

- If you wish to use a subroutine in a program, press the [SUB :] key after typing in the main routine. The main routine is stored in memory and " 1 :_ " indicator

appears in the display to prompt you to enter the subroutine. The indicator " 1 : _ " is the label number of your first subroutine. You can program a maximum of 10 subroutines per main routine.
The calculator sequentially labels all the subroutines to be stored with numbers 1 through 9 and 0, at the beginning of each subroutine line.

- If your main routine has no subroutine, press the ENT key after typing in the main routine. A message "Ø2: TITLE?" will appear in the display. (The title number may not be "Ø2" depending on the number of programs already stored).

NOTE:

1. The maximum length of an expression that you can write in one program line is 160 steps. Any characters and symbols entered in excess of this capacity are regarded as the 160th step and cause the character or symbol previously entered at that step to be rewritten. So, be sure to program each of your expressions within the capacity of 160 steps per line. If this is not possible, use subroutines.
2. Remember that in the STAT mode, the calculator cannot execute any of the programs you wrote in the AER mode.

Programming Formulas

Programs can easily be written so that when they are run (in COMP mode), they will ask you for values. There are two methods:

(1) Input format I
The f( )= key allows algebraic expressions to be entered in the form of:

f(A ~ Z) = Expression

by designating any of the memories A through Z as variables.

Example:

$f(AB) = A^2 + AB + B^2$

(2) Input format II

The [2ndF] [VAR] function allows lowercase letters (a ~ z), Greek letters (α, β, γ, θ), and numeric characters reduced in size to be entered. The calculator automatically regards all these characters in an expression as variables. Thus, an expression is entered in the form of:

Variables = Expression

└── lowercase letters, Greek letters (α, β, γ, θ), numeric characters reduced in size.

Example:

$c = a^2 + a \times b + b^2$

Characters for Variables

- In the AER mode, the calculator is put in the VAR (Variable Character Input) mode by pressing the [2ndF] and [VAR] keys. The VAR indicator appears in the display. Pressing these two keys a second time causes the calculator to exit from the VAR mode and the VAR indicator to disappear.

- In the VAR mode, the following keys are used to enter:

  [A] ~ [Z] : Lowercase letters

  [0] ~ [9] : Numeric characters reduced in size

  [RCL], [RM], [⇒M], [M+] : Greek letters (α, β, γ, θ)

- If one or more of these variable characters are used in succession such as "a1", the calculator automatically treats the character(s) as one variable. A maximum of seven variable characters may be used in succession.

Programming Examples

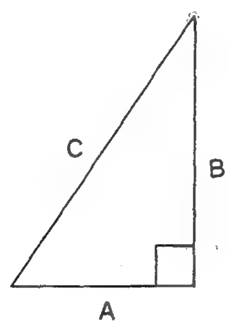
- Before you start the following programming and calculation examples, push the Reset switch to clear the memory contents. (See page 4 for operation of the Reset switch.)

```
ALL CLEAR ? →ENT
```

Check that the above message appears in the display and then press the [ENT] key.

Example 1: Pythagorean Theorem Program

To solve for the length of hypotenuse C in a right triangle with a given length on each of the other two sides A and B, where $C = \sqrt{A^2 + B^2}$ must be solved for in the form of $f(AB) = \sqrt{(A^2 + B^2)}$



(1) Programming

Mode: AER (AER mode)

```
Ø1:TITLE ?
```

[2ndF] [P] [Y] [2ndF] [T] [H] [A] [G] [2ndF] [O] [2ndF] [R] [A] [2ndF] [S] (title name is input)

```
Ø1:PYTHAGORAS_
```

[ENT] (title name is stored)

```
M:_
```

[f( )=] [A] [B] [f( )=] [√] [(] [A] [x^2] [+]
[B] [x^2] [)] (main routine is input)

```
M : f (A B) =√ (A 2 +B 2 ) _
```

[ENT] (main routine is stored)

```
Ø 2 : T I T L E ?
```

(2) Program Calculation (where A = 3, B = 4)

Mode: COMP (COMP mode)

```
                                    Ø.
```

[TITLE]

```
Ø 1 : P Y T H A G O R A S
```

[COMP]

```
A = ?
```

(The calculator is asking you for the value of A.)

3 [COMP]

```
B = ?
```

(The calculator is asking you for the value of B.)

4 [COMP]

```
A N S   1 =                          5.
```

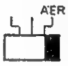
(Length of C is given as Answer 1)

● More than one algebraic expression may be written on a program line by separating them with the space [␣] or comma [,] key. If two expressions are separated by a space, the calculator will execute the expression immediately after the space without displaying the result of the expression immediately before the space. If they are separated by a comma, the calculator will display the result

of the preceding expression before proceeding to the following one.

Example 2: Plotting Program
To solve for f (A) = $3A^2 + 7A + 9$ with the value of A being as 1, 2, 3, ···

(1) Programming

Mode:  (AER mode)

```
Ø2:TITLE  ?
```

[2ndF] [P] [2ndF] [L] [2ndF] [O] [2ndF] [T]
[ENT]

```
M:_
```

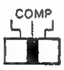
[A] [+] 1 [STO] [A] [,] 3 [A] [x²] [+]
7 [A] [+] 9

```
M:A+1⇒A, 3A²+7A+9_
```

[ENT]

```
Ø3:TITLE  ?
```

(2) Program Execution

Mode:  (COMP mode)

```
                              Ø.
```

[TITLE]

```
Ø2:PLOT
```

0 [STO] [A]

```
                              Ø.
```

[COMP]

```
ANS  1=                       1.
```

(A=1)

[COMP]

```
ANS  2=                      19.
```

(f(1))

[COMP]

```
ANS  1=                       2.
```

(A=2)

[COMP]

```
ANS  2=                      35.
```

(f(2))

NOTE:
In the above example, the number displayed to the right of "ANS" indicates that the answer is that of the 1st or 2nd expression separated by a comma.

Example 3:
Cosine Rule Program
$c = \sqrt{a^2 + b^2 - 2ab\cos\theta}$

(1) Programming

Mode: AER (AER mode)

```
Ø3:TITLE  ?
```

[C] [2ndF] [O] [2ndF] [S] [I] [2ndF] [N] [E]
[ENT]

```
M:_
```

[2ndF] [VAR] [C] [=] [√] [(] [A] [x^2]
[+] [B] [x^2] [−] [2ndF] [VAR] 2 [2ndF] [VAR]
[A] [×] [B] [COS] [θ] [)]

```
                                                    VAR
M : c=√(a²+b²−2a×bCOS  θ) _
```

[ENT]

```
Ø4:TITLE ?
```

(2) Program execution (where $a = 4$, $b = 7$, $\theta = 60°$)

Mode: COMP (COMP mode)

```
                                  Ø.
```

[TITLE]

```
Ø3:COSINE
```

[2ndF] [DRG] (Press until DEG is designated)
[COMP]

```
       DEG
a = ?
```

4 [COMP]

```
       DEG
b = ?
```

7 [COMP]

```
       DEG
θ = ?
```

60 [COMP]

```
       DEG
c =             6.Ø8276253
```

(length of C)

Variable data Check by Playback Function

When executing any of the programs (algebraic expressions) stored in memory, the calculator holds the number of value entered as a variable until the next input. To confirm the number already stored in memory, press the [PB] key and the number will be recalled to the display from memory.

Example:

Cosine Rule Program

$c = \sqrt{a^2 + b^2 - 2ab\cos\theta}$

Mode: COMP (COMP mode)

[TITLE]

```
Ø3:COSINE
```

[COMP]

```
a = ?
```

4 [COMP]

```
b = ?
```

7 [COMP]

```
θ = ?
```

60 [COMP]

```
c =                6. Ø8276253
```

[COMP]

```
a = ?
```

PB

a = 4

↑ Blinking cursol (The number stored in variable a is displayed.)

COMP

b = ?

Search Functions

- Title search

This function allows you to search the title names of the expressions stored in memory one by one (in ascending order of title numbers) at each depression of the TITLE key.

To execute any of the programs stored, you must perform the title search operation with the calculator in the COMP mode and then press the COMP key when the desired title is recalled on the display.

To correct any of the stored programs, you must perform the title search operation with the calculator in the AER mode, and then press the ↓ key to display the program contents when the desired title is recalled on the display.

NOTE:

1. The TITLE key causes title names to be displayed, commencing with the one last accessed.
2. The TITLE key may be pressed and held down to search title names quickly in ascending order.
3. Title names can be searched in the descending order of title numbers by pressing the 2ndF and TITLE keys. Holding down the TITLE after 2ndF allows quick review of title in descending order.

● Direct search

Enter the first character (or several characters from the beginning) of the title name you want to search and then press the [TITLE] key. The title names commencing with the designated character string can now be accessed directly.

Example:

To search a program named "COSINE"

[C] [2ndF] [O] [TITLE]

```
Ø3:COSINE
```

If none of the programs commencing with characters "CO" exists in memory, the calculator will return the following message to you.

```
NOT FOUND
```

NOTE:

The direct search function is effective only for the alphabetic and numeric characters. If a title name has been entered using function keys such as [SIN] and [COS], such a title name cannot be searched directly even though the key operation: [2ndF] [S] [TITLE] or [C] [TITLE] is performed. A message "NOT FOUND" is also displayed in this case.

Conditional Expression Judgment Function

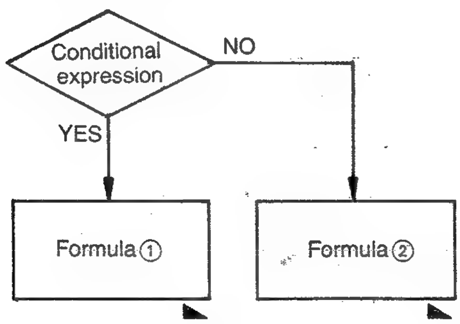
The EL-5150 compares the left side of a conditional expression (in which >, >=, or ≠ sign is used) with its right side, and determines the destination of the calculation to be executed next based on the result of the comparison. If the condition in the conditional expression is satisfied, the calculator executes the calculation or operation enclosed with brackets preceded by –Y→. If not satisifed, the unit executes the calculation or operation enclosed with brackets preceded by –N→.

NOTE:
A conditional expression cannot be used inside the –Y→ [ ] or –N→ [ ] brackets.

You can write a conditional expression in the following forms:

Left side > Right side	Is left side greater than right side?
Left side ≠ Right side	Is left side unequal to right side?
Left side >= Right side	Is left side equal to or greater than right side?

Example 1:
Flowchart of Conditional Judgement Function



In the conditional expression as shown in the above flowchart, if a given condition is satisfied (if YES), formula 1 is executed. If a given condition is unsatisfied (if NO), formula 2 is executed. This decision is made using the -Y→[] and -N→[] keys.

Conditional
expression –Y→ [Formula 1 ◣] – N → [Formula 2 ◣]

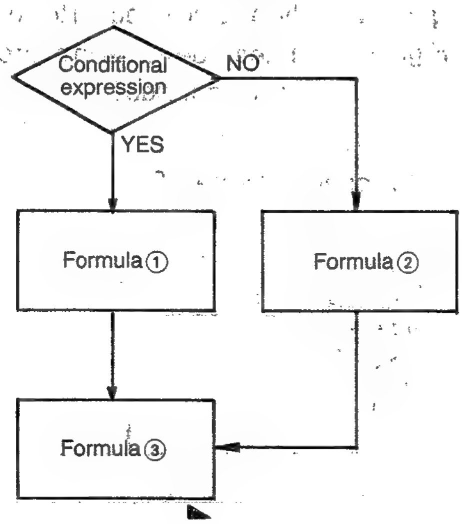
NOTE:

Either of –Y→ [ ] or – N→ [ ] may be omitted from entry as shown below.

Conditonal
expression –Y→ [Formula 1 ◣] Formula 2 ◣

Example 2:

Flowchart of Conditonal Judgement Function



In the conditional expression as shown in the above flowchart,
If YES, formula ③ is executed after formula ①. If NO, formula ③ is executed after formula ②.

Conditional
expression –Y→ [Formula ①] – N→ [Formula ②]

Formula ③ ◣

- To terminate a series of calculations, [2ndF] [◣] (Calculation End Command) must be entered after the last formula in the series.

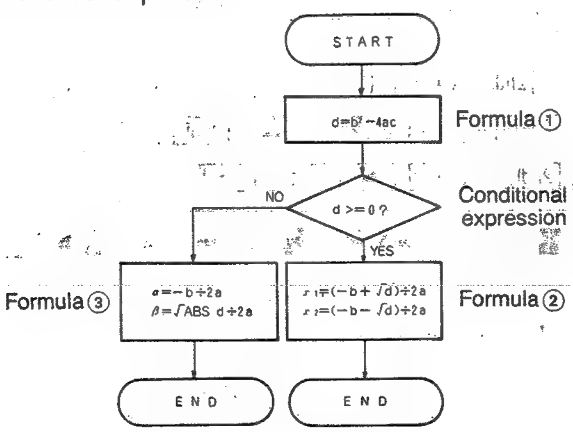
Example 3: Quadratic equation

Let's solve for $ax^2 + bx + c = 0$, where $a \neq 0$ and a, b, and c are real numbers.
The quadratic equation can be solved by the following formula:

$$x = \frac{-b \pm \sqrt{(b^2 - 4ac)}}{2a}$$

With the value of the discriminant $d = b^2 - 4ac$ under $\sqrt{\ }$, real numbers are solved for if $d \geq 0$, and conjugate imaginary numbers are solved for if $d < 0$.

- Flowchart of expression



Formula ① is a discriminant.
Conditional expression determines if the value of the discriminant is equal to or greater than 0.
Formula ② solves for real numbers.
Formula ③ solves for imaginary nubmers (where α is the real part and β is the imaginary part).

- Input format of expression

Formula ① Conditional expression – Y→ [Formula ② ◣]
– N → [Formula ③ ◣]

Formula ② to be stored in subroutine
Formula ③ to be stored in subroutine

(1) Programming

Mode: AER (AER mode)

```
Ø4:TITLE  ?
```

[2ndF] [Q] [2ndF] [U] [A] [D] [2ndF] [R] [A]
[2ndF] [T] [I] [C] [␣] [E] [2ndF] [Q] [2ndF]
[U] [A] [2ndF] [T] [I] [2ndF] [O] [2ndF] [N]
[ENT]

```
M:_
```

[2ndF] 1 [2ndF] [VAR] [D] [2ndF] [>=] [2ndF] [VAR]
0 [2ndF] [-Y→[]] [2ndF] 2 [2ndF] [◣] [2ndF] [-Y→[]] [2ndF]
[-N→[]] [2ndF] 3 [2ndF] [◣] [2ndF] [-N→[]]

```
M:1d>=Ø -Y→[2◣] -N→[3◣]_
```

[SUB:] (main routine is stored)

```
1:_
```

[2ndF] [VAR] [D] [=] [B] [x^2] [−] [2ndF] [VAR]
4 [2ndF] [VAR] [A] [×] [C]

1 : d=b² −4 a×c_ VAR

[SUB :] (Subroutine 1 is stored)

2 : _

[2ndF] [VAR] [X] 1 [=] [(] [(−)] [B] [+] [√]
[D] [)] [÷] [2ndF] [VAR] 2 [2ndF] [VAR] [A] [,]

2 : χ 1 = (− b+√d) ÷2 a, _ VAR

[X] 2 [=] [(] [(−)] [B] [−] [√] [D] [)]
[÷] [2ndF] [VAR] 2 [2ndF] [VAR] [A]

← − b+√d)÷2 a,χ 2= (− b−√d) ÷2 a_ VAR

[SUB :] (Subroutine 2 is stored)

3 : _

[2ndF] [VAR] [α] [=] [(−)] [B] [÷] [2ndF] [VAR] 2
[2ndF] [VAR] [A] [,] [β] [=] [√] [2ndF] [ABS]
[D] [÷] [2ndF] [VAR] 2 [2ndF] [VAR] [A]

3 : α=−b÷2 a, β=√ABS d÷2 a_ VAR

[ENT] (Subroutine 3 is stored, and the program is completed)

Ø5 : TITLE ?

(2) Program execution (where a=2, b=−4, c=1)

Mode: (COMP mode)

Ø.

[TITLE]

Ø4 : QUADRATIC EQUATION

[COMP]

b = ?

[(−)] 4 [COMP]

a = ?

2 [COMP]

c = ?

1 [COMP]

X_1 = 1.7Ø71Ø6781

[COMP]

X_2 = Ø.292893219

Looping Function

The looping function permits the same calculation or processing to be repeated over and over again. This function is designated in a series of calculation procedures by using two commands: " ↳ " (Return here) and " ↰ " (Return from here to " ↳ " command).
The basic looping format is as shown below.

```
↳ Formula ①
Conditional expression
   — Y→ [ ↰ ]
   — N→ [Formula ②◣]
```

If YES, execution returns to formula ①, and If NO, formula ② is executed.

NOTE:
Up to 15 loops can be nested.

Example:
Double-looped conditional expressions

```
↳
Formula ①
↳
Formula ②
Conditional expression ①
— Y→[ ↰ ]
— N→ [Formula ③]
Conditional expression ②
— Y→ [ ↰ ]
— N→ [ Formula ④ ◣ ]
```

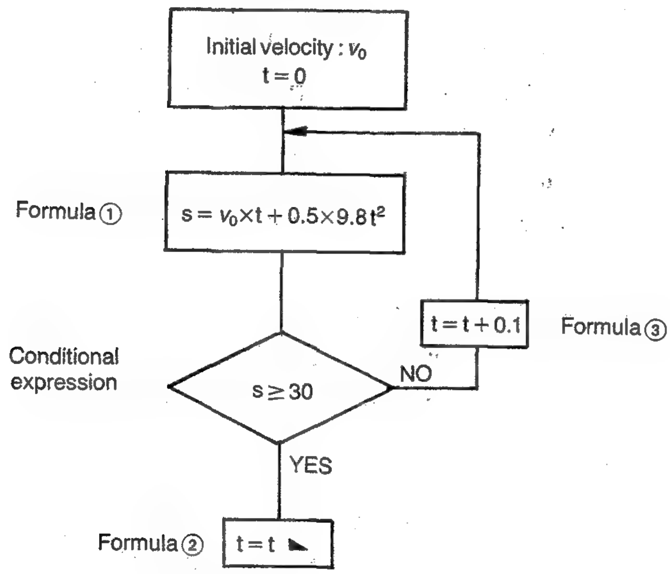
NOTE:
>, >=, ≠, − Y→ [ ], − N→ [ ], ↳, and ↰
cannot be used in a subroutine.

Let's write a program expression using both the conditional judgement and looping functions.

Example: Program "DOWN"
To solve for the approximate value of the time when a ball falling from the point 30 meters above the ground at the initial velocity of v_0 (m/s) reaches the ground

Falling distance $s = v_0 \times t + 0.5 \times 9.8t^2$

- Flowchart of expression



● Input format of expression

↳ Formula ① conditional expession – Y→ [Formula ② ►]

– N→ [Formula ③ ↰]

(1)Programming

Mode: AER (AER mode)

Ø5: TITLE ?

[D] [2ndF] [O] [2ndF] [W] [2ndF] [N]

Ø5: DOWN_

[ENT]

M: _

[2ndF] [↳] [2ndF] [VAR] [2ndF] [S] [=] [2ndF] [V]
0 [×] [2ndF] [T] [+] [2ndF] [VAR] 0.5 [×] 9.8
[2ndF] [VAR] [2ndF] [T] [x^2] [␣]

M: ↳ s = v_0 × t + Ø. 5 × 9. 8 t^2 ␣ _ VAR

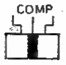
[2ndF] [S] [2ndF] [>=] [2ndF] [VAR] 30 [2ndF] [-Y→[]] [2ndF]
[VAR] [2ndF] [T] [=] [2ndF] [T] [2ndF] [►] [2ndF] [-Y→[]]
[2ndF] [-N→[]] [2ndF] [T] [=] [2ndF] [T] [+] [2ndF] [VAR]
0.1 [2ndF] [↰] [2ndF] [-N→[]]

← Ø -Y→ [t = t ►] -N→ [t = t + Ø. 1 ↰] _

[ENT]

Ø6: TITLE ?

(2) Program execution (where $v_0 = 3, t = 0$)

Mode: 

(COMP mode)

```
                                       Ø.
```

[TITLE]

```
Ø5:DOWN
```

[COMP]

```
v0 =
```

3 [COMP]

```
t =
```

0 [COMP]

```
t =                           2. 2
```

(The approximate value is 2.2 seconds.)

Correction of Title Name Entry

During the input of a program in the AER mode, if you find an error in the title name of the program, press the [◄] or [►] key to move the cursor to the point where an incorrectly entered character exists. Enter the correct character at the point where the cursor blinks.

- The [DEL] key causes the character at the cursor position to be deleted.
- The [2ndF] and [INS] keys cause all the characters at the right of the cursor position to move to the right by one digit. Then the "□" indicator appears at the cursor position to prompt you to insert the correct character at that position.

Example 1:

To correct the title name erroneously entered during programming to read from "COSSAIN" to "COSSINE."

Mode: (AER mode)

```
Ø6:TITLE ?
```

[C] [2ndF] [O] [2ndF] [S] [2ndF] [S] [A] [I] [2ndF] [N]

```
Ø6:COSSAIN_
```

[◄] [◄] [◄] [I] [2ndF] [N] [E]

```
Ø6:COSSINE_
```

(Title name is corrected.)

[ENT]

```
M:_
```

(Title name is stored.)

[2ndF] [VAR] [C] [=] [√] [(] [A] [x^2] [+] [B]

[x^2] [−] [2ndF] [VAR] 2 [2ndF] [VAR] [A] [×] [B]

[COS] [θ] [)]

M : c=√(a ² +b ² −2 a×b COS θ) _

[ENT]

Ø 7 : T I T L E ?

● To correct the incorrect title name of the program stored in memory, recall the title of the program by performing the title search operation in the AER mode. The title name can then be corrected in the same manner as in example 1.

Example 2:
To correct the erroneously entered title name of the program stored in memory to read from "COSSINE" to "COSINE"

[TITLE]

Ø 6 : C O S S I N E

(Title search function.)

[▶] [▶] [▶] [▶] [DEL]

Ø 6 : C O S I N E

(Title name is corrected.)

[ENT]

M : c=√(a ² +b ² −2 a×b COS θ)

(Title name is stored.)

[ENT]

Ø 7 : T I T L E ?

In either case, be sure to press the [ENT] key at the end of the correction.

Correcting Program Contents

- To correct the contents of a program (one or more algebraic expressions) stored in memory, perform the title search operation in the AER mode to recall the title of the program you wish to correct on the display. Then press the [↓] key and the contents of the main routine will be displayed. If the program has any subroutines, press the [↓] key consecutively to display the subroutines. As you did in the title name correction, move the cursor to the point on a program line where you wish to make corrections and then enter character(s) for correction.

- Press the [ENT] key after you have completed the correction of each main or subroutine line.

NOTE:
Variable characters (see page 68) will be cleared as a result of correcting an expression in the program.

Deleting or Clearing Program Contents

- To delete a specific program line (an algebraic expression) from a program, call the title of the program you wish to delete on the display using the [TITLE] key, locate the line to be deleted, using the [↓] key in the AER mode, and then press the [2ndF] and [CA] keys. The line has now been deleted from memory.

- To delete a specific program from memory, call the title of the program you wish to delete on the display by the title search operation in the AER mode, and press the [2ndF] and [CA] keys. The following message will appear on the display.

```
OO:CLEAR ? →ENT
```

Then press the [ENT] key and the program (title name, main routine, and subroutines) will be deleted from memory. Memory contents will be retained by pressing the [ON/C] key.

● To clear all the programs stored in memory, push the Reset switch at the rear of the calculator in the AER mode, and the following message will appear on the display.

```
ALL  CLEAR ? →ENT
```

Then press the [ENT] key and all the programs stored in the AER mode will be cleared from memory. Memory contents will not be cleared when any key other than [ENT] is pressed.

CHAPTER 4
DISPLAY SYSTEMS & DECIMAL PLACES

Display Systems

The EL-5150 has four different display systems which can be selected with the [FSE] (display mode control) key.

When you press the [FSE] key in the COMP mode, the display mode indicator "FIX", "SCI", or "ENG" or a blank (none of these) will appear at the upper part of the display. The [FSE] key is operative only after the result of a calculation has been displayed or when calculator is cleared with [ON/C] key.

FIX → SCI → ENG → Blank (Reset) → (back to FIX)

Fixed decimal places (FIX, SCI, ENG)
(See "decimal places" later)

Floating decimal place (Blank (Reset))

The designated decimal point system and decimal places will be retained even when the calculator is turned off.

(1) FIX (FIXed decimal point system)

- Each calculation result is displayed after being rounded to the number of decimal places selected with the [TAB] key.
- When a calculation result is to be used for further calculations or formulas, the contents displayed will be used.

When the absolute value of a calculation result is less than 1, the result may be displayed in the exponential form (scientific notation) accoridng to the number of decimal place selected with the [TAB] key.

Example 1:
If the absolute value of a calculation result is 1 or more

ON/C FSE (To display FIX indicator)

TAB 3 (To fix the number of decimal places to 3)

5 ÷ 3 =

FIX 1. 667

×

FIX 1. 667×_

Example 2:
If the absolute value of a calculation result is less than 1

ON/C 5 ÷ 9 =

FIX 0. 556

×

FIX 5. 556E−01×_

(2) SCI (SCIentific notation)

- Calculation result is displayed with scientific notation ($A \times 10^B$).
Since the mantissa part of the calculation result is displayed in accordance with the decimal place designation (TAB), the number of significant digits can be easily designated. The next digit after the specified number of decimal places is automatically rounded off.

- When a calculation result is to be used for further calculations or formulas, the contents displayed will be used.

Example:

[ON/C] [FSE] (To display SCI indicator)

[TAB] 2 (To fix the number of decimal places to 2)

0.3 [÷] 7 [=]

SCI 4. 29E−Ø2

[+]

4. 29E−Ø2+_ SCI

The above display means that the number of significant digits has been fixed to 3.

(3) ENG (ENGineering notation)

- Each calculation result is displayed on the basis of scientific notation ($A \times 10^B$). At this time its mantissa is displayed according to the decimal place designation (TAB) and the exponent is automatically set to a multiple of 3 (··· -6, -3, 0, 3, 6,···) for display. Therefore, any display can be easily read in units of K (kilo- 10^3) or m (milli- 10^{-3}), etc. that is commonly used in the engineering field.

- When a calculation result is to be used for further calculations or formulas, the contents displayed will be used.

(The next digit after the specified number of decimal places is automatically rounded off.)

Example:

[ON/C] [FSE] (To display ENG indicator)

[TAB] 2 (To fix the number of decimal places to 2)

0.3 [÷] 7 [=]

ENG 42. 86E−Ø3

$\boxed{\times}$

ENG
42.86E–03×_

(4) Blank (i.e., when none of FIX, SCI, and ENG is displayed)

● Each calculation result is displayed in the floating decimal point system.
Calculation result x is displayed on the basis of scientific notation if it is outside the range of $0.000000001 \leq |x| \leq 9999999999$ or not zero.

● When a calculation result is to be used for further calculations or formulas, the calculator will secure as many significant digits as possible (10 digits max.) for the next formula.

Example 1:

If the absolute value of a calculation result is 1 or more

[ON/C] [FSE] (To display FIX indicator)

[TAB] 3 (To fix the number of decimal places to 3)

5 [÷] 3 [=]

FIX	1. 667

[×]

1. 667×_	FIX

Example 2:

If the absolute value of a calculation result is less than 1

[ON/C] 5 [÷] 9 [=]

FIX	0. 556

[×]

5. 556E−01×_	FIX

(2) SCI (SCIentific notation)

- Calculation result is displayed with scientific notation ($A \times 10^B$).

Since the mantissa part of the calculation result is displayed in accordance with the decimal place designation (TAB), the number of significant digits can be easily designated. The next digit after the specified number of decimal places is automatically rounded off.

- When a calculation result is to be used for further calculations or formulas, the contents displayed will be used.

Example:

[ON/C] [FSE] (To display SCI indicator)

[TAB] 2 (To fix the number of decimal places to 2)

0.3 [÷] 7 [=]

SCI	4. 29E−02

[+]

4. 29E−02+_	SCI

The above display means that the number of significant digits has been fixed to 3.

(3) ENG (ENGineering notation)

- Each calculation result is displayed on the basis of scientific notation ($A \times 10^B$). At this time its mantissa is displayed according to the decimal place designation (TAB) and the exponent is automatically set to a multiple of 3 (··· -6, -3, 0, 3, 6,···) for display. Therefore, any display can be easily read in units of K (kilo- 10^3) or m (milli- 10^{-3}), etc. that is commonly used in the engineering field.

- When a calculation result is to be used for further calculations or formulas, the contents displayed will be used.

(The next digit after the specified number of decimal places is automatically rounded off.)

Example:

[ON/C] [FSE] (To display ENG indicator)

[TAB] 2 (To fix the number of decimal places to 2)

0.3 [÷] 7 [=]

ENG	42. 86E−03

$\boxed{\times}$

4 2 . 8 6 E − Ø 3 ×_ ENG

(4) Blank (i.e., when none of FIX, SCI, and ENG is displayed)

- Each calculation result is displayed in the floating decimal point system.

Calculation result x is displayed on the basis of scientific notation if it is outside the range of $0.000000001 \leq |x| \leq 9999999999$ or not zero.

- When a calculation result is to be used for further calculations or formulas, the calculator will secure as many significant digits as possible (10 digits max.) for the next formula.

Decimal Places

The [TAB] key is used to specify the number of decimal positions in a calculation result when the FIX, SCI, or ENG mode is set. The number of decimal places is specified by the numeral key ([0] - [9]) following the [TAB] key. Carry over will be automatically rounded.
Use the [TAB] key when the calculation result is displayed or when the calculator is cleared with the [ON/C] key.

Example:
If FIX mode is designated

[ON/C] [FSE] (To display FIX indicator)

[TAB] 9 (To fix the number of decimal places to 9)

5 [÷] 9 [=]

FIX Ø. 555555556

[TAB] 8 (To fix the number of decimal places to 8)

FIX Ø. 55555556

[TAB] 7 (To fix the number of decimal places to 7)

FIX Ø. 5555556

[TAB] 0

FIX 1.

Note:

1. If a number cannot be displayed in the number of decimal places specified by [TAB], the number may be displayed in less than the number of decimal places specified by [TAB].
2. The designated number of decimal places is retained even when the display system is changed or when the power is turned off.

Indicators

← : Indicates that the information (a portion of an expression or formula) that has already been displayed exists at the left of the information (a portion of the expression or formula) now on the display.

→ : Indicates that the information yet to be displayed continues to the right of the information now on the display. Also indicates that the calculator is performing a calculation.

2ndF : Indicates that the second function of another key has been specified.

HYP : Indicates that the hyperbolic function has been specified.

DEG : Indicates that "degrees" must be used as the angle of unit for the calculation.

RAD : Indicates that "radians" must be used as the angle of unit for the calculation.

GRAD: Indicates that "grads" must be used as the angle of unit for the calculation.

FIX : Indicates that the result of a calculation is to be displayed in the fixed decimal point system.

SCI : Indicates that the result of a calculation is to be displayed in the scientific notation system.

ENG : Indicates that the result of a calculation is to be displayed in the engineering notation system.

BIN : Indicates that the calculator is in the BIN (binary number system) mode or that the displayed number is a binary number.

OCT : Indicates that the calculator is in the OCT (octal number system) mode or that the displayed number is an octal number.

HEX : Indicates that the calculator is in the HEX (hexadecimal number system) mode or that the displayed number is a hexadecimal number.

STAT : Indicates that the calculator is in the STAT (statistical calculation) mode.

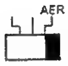
VAR : Indicates that the calculator is in the VAR (variable character input) mode.

APPENDIXES

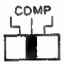
Appendix A
Operating Controls

Unless otherwise specified, the keys listed below can be used in either the COMP or AER mode.

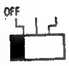
Mode Selector (Slide Switch)



AER: Algebraic Expression Reserve Mode
This mode is used to program algebraic expressions into the calculator's memory. In this mode, no calculation can be performed.



COMP: Compute mode
This mode permits the calculator to perform all calculations including four basic arithmeric operations, scientific calculations, statistical calculations, and calculations that use algebraic expressions programmed in the AER mode.



OFF: Setting the switch in this position turns off the power supply of the calculator. Sliding the switch from the OFF position to the COMP or AER turns on the power supply of the calculator.

[2ndF] : 2nd Function Key
Used to designate the second function of another key. The second function is printed in brown above the key top.
NOTE: If this key is pressed by mistake, press the key again to cancel the second function designation.

[ON/C] : ON/Clear Key

When the Auto Power-Off feature is active, pressing this key causes the calculator to turn on. This key is also used to release the calculator from an error condition.

COMP mode:

Used to clear numeric data or calculation commands from the display. The memory contents or programs will remain unchanged even after the clear operation. Pressing this key during a program execution breaks the execution.

AER mode:

Used to move the cursor to the beginning of the current line. If this key is pressed while a program title (with no cursor) is in the display, the title will be replaced with a message "00 :TITLE?".

[2ndF] [CA] : Clear All Key

COMP mode:

Used to clear numeric data or calculation commands. The memory contents or programs will remain unchanged even after the clear operation. Also used to clear the result of a statistical calculation or statistical data entered in the STAT mode. (The contents of memories A ~ T will remain unchanged.)

AER mode:

If these keys are pressed while program contents are in the display, the program line now in the display will be cleared. If they are pressed while a program title is in the display, the title will be replaced with a message "00: CLEAR? → ENT". Pressing the [ENT] key will delete the program of that title.

[FSE] : Display Mode Designation Key

COMP mode:

Used to select the display mode from FIX, SCI, and ENG.

[2ndF] [DRG] : Degrees/Radians/Grads Selection Key

Used to designate the unit of angle (DEG, RAD, or GRAD) for calculation of trigonometric and inverse trigonometric functions and for conversion of coordinates. Each depression of these keys causes the unit of angle to be changed from one unit to another.

Example: DEG → GRAD: Press the [2ndF], [DRG] keys twice.

"DEG" - Entries and answers are in decimal degrees.

"RAD" - Entries and answers are in radians.

"GRAD" - Entries and answers are in grads.

$(100g=90°=\frac{\pi}{2}\ (RAD))$

[COMP] : Compute Key

COMP mode:

Used to execute a stored program (algebraic expression).

[PB] : Playback Key

COMP mode:

Pressing this key allows you to check or correct all of the inputs or to display the last executed expression for re-execution. The input or expression called is displayed in 24-step segments.

AER mode:
Used to display the contents of the program line in 24-step segments.

[DEL] : Delete Key
Used to delete the character (number or letter) at the cursor position. (The cursor does not move.)

[2ndF] [INS] : Insert key
Provides a blank space necessary for insertion of a character (number or letter) into the cursor position. Pressing the [2ndF] and [INS] keys in this sequence shifts the contents of the display to the right. In the blank space, the insert mark "⊐" appears.

[◄] : Cursor Step-Down Key
Used to move the cursor left by one step. While this key is being pressed and held, the cursor moves left in quick succession.

[►] : Cursor Step-Up Key
Used to move the cursor right by one step. While this key is being pressed and held, the cursor moves right in quick succession.

[Exp] : Exponent Key
Used to enter the exponent part of a number.
Example: 1.234×10^{15}
Key in: 1.234 [Exp] 15

NOTE:
The number of digits for the exponent part is 2 digits. A number with a decimal fraction may be entered, but the calculator ignores the decimal point in the calculation process. If more than two digits are entered, only the last two digits are effective as the exponent.
Example: COMP mode
Key in: 2 [Exp] 1234 [=] → "2. E 34" is displayed.

[TAB] : Tabulation Key
COMP mode:
Used to fix the number of decimal positions in a calculation result. The number of digits (0 ~ 9) must be entered following this key.

[2ndF] [ANS] : Recall Answer Memory Key
Used to recall the data stored in the answer memory.

[2ndF] [M.CK] : Memory Check Key
The remaining capacity of the memory is indicated in bytes on the display while these keys are being pressed and held.

[2ndF] [MDF] : Modify Key
COMP mode:
Used to match the internal calculation result with the calculation result in the display.

[+] : Plus Key
Pressed for addition.

[−] : Minus Key
Pressed for subtraction.

[×] : Multiplication Key
Pressed for multiplication.

[÷] : Division Key
Pressed for division.

[=] : Equals Key
Used to obtain the result of a calculation.

[0] ~ [9] : Numeral Keys
Used to enter numeric data.
Example: 1 2 3 4 → [1] [2] [3] [4]

NOTE:
These keys are also used to enter numbers 0 ~ 9 reduced in size as variables in the VAR mode.

[(] : Open Parenthesis Key
Used to enter an open parenthesis.

[)] : Closed Parenthesis Key
Used to enter a closed parenthesis.

[(–)] : Change Sign Key
Used to enter a negative number.
Example: –2.4 → [(–)] [2] [•] [4]

[•] : Decimal Point Key
Used to place the decimal point in the number entered.
Example: 12.3 → [1] [2] [•] [3]

[STO] : Store Key

Used to store a number in each of the 26 memories [A] ~ [Z] by pressing this key followed by one of the [A] - [Z] keys. When these keys (for example, [STO] [A]) are pressed after a number (or a calculation result), the number is stored in memory A by clearing the contents previously stored in the memory.

[RCL] : Recall Key

Used to recall the contents of the designated memory. To recall each of the 26 memories A ~ Z, depress one of the [A] - [Z] keys following the [RCL] key. (Example: [RCL] [B])

[A] ~ [Z] : Memory Designation Keys

AER mode, COMP mode:

When one of the [A] - [Z] keys is pressed following the [STO] or [RCL] key, the corresponding store memory is designated.

VAR mode:

Used to enter lowercase letters (a to z) as variables.

[RM] : Recall Memory Key

Used to recall and display the contents of the independently accessible memory.

[⇒M] : Memory In Key

Used to store a calculation result in the independently accessible memory. When this key is pressed, the previous contents of the independently accessible memory is cleared and replaced with the calculation result. To clear the independent accessible memory, depress the [ON/C] key followed by the [⇒M] key. (In this case, 0 (zero) is stored in the memory.)

[M+] :Memory Plus Key

Used to add a calculation result to the contents of the independently accessible memory.

[2ndF] [M+] : Memory Minus Key

Used to subtract a calculation result from the contents of the independently accessible memory.

[→DEG] : D.MS → Decimal Degrees Conversion Key

Used to convert an angle in the sexagenary notation system (degrees, minutes, seconds) into decimal equivalent (in degrees).

[2ndF] [→D.MS] : Decimal Degrees → D.MS Conversion Key

Used to convert an angle in the decimal notation system (in degrees) into sexagenary equivalent (in degrees, minutes, seconds).

[2ndF] [FRAC] : Fraction Key

Used to determine and display the fraction part of a number.

2ndF INT : Integer Key
Used to determine and display the integer part of a number.

2ndF ABS : Absolute Value Key
Used to determine and display the absolute value of a number.

π : Pi Key
Used to enter the constant π (π = 3.141592654).

Y^x : Power Key
Used to raise a number to a power.

2ndF $\sqrt[x]{\ }$: Power Root Key
Used to obtain the power root of a number.

x^2 : Square Key
Used for squaring.

$\sqrt{\ }$: Square Root Key
Used for square root calculations.

2ndF $\sqrt[3]{\ }$: Cubic Root Key
Used for cubic root calculations.

2ndF 10^x : Common Antilogarithm Key
Used to calculate the antilogarithm with base 10.

LN : Natural Logarithm Key
Used to obtain the logarithm with base e (e ≒ 2.718281828).

2ndF e^x : Natural Antilogarithm Key
Used to calculate the antilogarithm with base e of the displayed number.

LOG : Common Logarithm Key
Used to obtain the logarithm with base 10.

2ndF x^{-1} : Reciprocal Key
Used for reciprocal calculations.

HYP : Hyperbolic Function Key
Used with the respective trigonometric function keys to calculate hyperbolic functions (SINH, COSH, TANH).

2ndF ARCHYP : Inverse Hyperbolic Function Key
Used with the respective trigonometric function keys to calculate inverse hyperbolic functions ($SINH^{-1}$, $COSH^{-1}$, $TANH^{-1}$).

SIN COS TAN : Trigonometric Function Keys
Used to calculate the respective trigonometric functions.

2ndF SIN^{-1} 2ndF COS^{-1} 2ndF TAN^{-1} : Inverse Trigonometric Function Keys
Used to calculate the respective inverse trigonometric functions.

→POL : Rectangular → Polar Coordinates Conversion Key
Used to convert rectangular coordinates into polar coordinates.

2ndF →REC : Polar → Rectangular Coordinates Conversion Key
Used to convert polar coordinates into rectangular coordinates.

2ndF $n!$: Factorial Key
Used to calculate the factorial n! = n (n-1) (n-2) ..... 2·1.

nCr : Combinations Key
Used to determine the number of possible combinations when selecting a specific number of items (r) from any number of different items (n).

2ndF nPr : Permutations Key
Used to determine the number of possible permutations when arranging a specific number of items (r) selected from any number of different items (n).

2ndF →BIN : Binary Number Mode Key
COMP mode:
Used to set the binary number system mode. Also used to convert the number displayed into a binary number.

2ndF →OCT : Octal Number Mode Key
COMP mode: Used to set the octal number system mode. Also used to convert the number displayed into an octal number.

2ndF →HEX : Hexadecimal Number Mode key
COMP mode:
Used to set the hexadecimal number system mode. Also used to convert the number displayed into a hexadecimal number.

2ndF →DEC : Decimal Number Mode Key
COMP mode:
Used to set the decimal number system mode (normal mode). Also used to convert the number displayed into a decimal number.

NEG : Negative Key
BIN, OCT, or HEX mode:
Used to obtain the negative counterpart of a number.

Hexadecimal Number Key
HEX mode:

A : Used to enter hexadecimal number "A".

B : Used to enter hexadecimal number "B".

C : Used to enter hexadecimal number "C".

D : Used to enter hexadecimal number "D".

E : Used to enter hexadecimal number "E".

F : Used to enter hexadecimal number "F".

Logical Operator Keys
BIN, OCT, HEX mode:

NOT NOT Key
: Used to enter logical operator "NOT".

AND : AND Key
Used to enter logical operator "AND".

OR : OR Key
Used to enter logical operator "OR".

XOR : Exclusive OR Key
Used to enter logical operator "XOR" (exclusive OR).

XNOR : Exclusive NOR Key
Used to enter logical operator "XNOR" (exclusive NOR).

[2ndF] [STAT] : Statistical Calculation Mode Key

COMP mode:

Used to set or reset the STAT (statistical calculation) mode. When the calculator is set in this mode by these keys, the " STAT " indicator appears, and at the same time the numeric values and calculation commands, except for memory contents are cleared.

[(x,y)] : Two-Variable Data Designation Key

STAT mode:

Used to distinguish between data x and data y in two-variable statistical calculations.

[DATA] : Enter Data Key

STAT mode:

Used to enter data in single- or two-variable statistical calculations.

[CD] : Correct Data Key

STAT mode:

Used to correct an error in statistical data entry.

Statistical Calculation Keys

STAT Mode:

[2ndF] [n] : Used to obtain the number of samples (data) entered in single- or two-variable statistical calculations.

[2ndF] [Σx] : Used to obtain the sum of data x entered in single- or two-variable statistical calculations.

[2ndF] [Σy] : Used to obtain the sum of data y entered in two-variable statistical calculations.

$\boxed{2ndF}$ $\boxed{\Sigma xy}$: Used to obtain the sum of the products of data x and y in two-variable statistical calculations.

$\boxed{2ndF}$ $\boxed{\Sigma x^2}$: Used to obtain the sum of the squares of each data x entered in single- or two-variable statistical calculations.

$\boxed{2ndF}$ $\boxed{\Sigma y^2}$: Used to obtain the sum of the squares of each data y entered in two-variable statistical calculations.

$\boxed{2ndF}$ $\boxed{\bar{x}}$: Used to obtain the mean value of data x entered in single- or two-variable statistical calculations.

$\boxed{2ndF}$ $\boxed{\bar{y}}$: Used to obtain the mean value of data y entered in two-variable statistical calculations.

$\boxed{2ndF}$ $\boxed{\sigma x}$: Used to obtain the standard deviation (σx) of the population of data x entered in single- or two-variable statistical calculations.

$\boxed{2ndF}$ $\boxed{\sigma y}$: Used to obtain the standard deviation (σy) of the population data y entered in two-variable statistical calculations.

$\boxed{2ndF}$ $\boxed{Sx}$: Used to obtain the standard deviation (sx) of the sample of data x entered in single- or two-variable statistical calculations.

$\boxed{2ndF}$ $\boxed{Sy}$: Used to obtain the standard deviation (sy) of the sample of data y entered in two-variable statistical calculations.

[2ndF] [(x')] : Used to obtain the estimated value of x. (In linear regression equation $\hat{y} = a + bx$, the value of *x* is estimated from that of y.)

[2ndF] [(y')] : Used to obtain the estimated value of y. (In linear regression equation $\hat{y} = a + bx$, the value of $\hat{y}$ is estimated from that of x.)

[2ndF] [(a)] : Used to obtain the constant a of linear regression equation $\hat{y} = a + bx$.

[2ndF] [(b)] : Used to obtain the coefficient b of linear regression equation $y = a + bx$.

[2ndF] [(r)] : Used to obtain the correlation coefficient between two variables (or data) *x* and y.

Program Title Search Keys

[TITLE] : Used to search program titles in the ascending order of title numbers. While this key is being pressed and held, program titles are searched in quick succession.

[2ndF] [TITLE] : Used to search program titles in the descending order of title numbers.

Program Scroll Keys
AER mode:

[↓] : Used to scroll a stored program one line after another in the forward direction. While this key is being pressed and held, program lines are scrolled in quick succession.

[2ndF] [↑] : Used to scroll a stored programs one line after another in the reverse direction.

ENT : Enter Key
AER mode:
Used to store a program (algebraic expression) in memory.

2ndF ◣ : End Command Key
AER mode:
Used to terminate program execution. (These keys are used as the End command of an algebraic expression.)

Looping Keys
AER mode:

2ndF ↳ : Used to specify the destination of a jump caused by the " ↰ " command.

2ndF ↰ : Used to cause program execution to jump to the point where the " ↳ " command is located.

Compare Keys
AER mode:

2ndF > : Used to determine if the magnitude of the left side of an expression is greater than that of its right side.

2ndF >= : Used to determine if the magnitude of the left side of an expression is equal to or greater than that of its right side.

2ndF ≠ : Used to determine if the left side of an expression is not equal to its right side.

SUB : Subroutine Key
AER mode:
Used for writing a subroutine.

Conditional Jump Destination keys
AER mode:

[2ndF] [Y→[]] :Used to specify the destination of a jump if the result of conditional expression judgment is “Yes”.

[2ndF] [N→[]] : Used to specify the destination of a jump required if the result of conditional expression judgmends is “No”.

[␣] : Space Key
AER mode:
Used to enter spaces (␣) which are used to separate two or more expressions or formulas in a program to be stored.

[,] : Comma Key
AER mode:
Used to enter commas (,) which are used to separate two or more expressions or formulas in a program to be stored.

[f( )=] : Variable Designation Key
AER mode:
Used to designate store memories (A~ Z) as the variables of an expression or formula. For example, when you press [f( )=] [A] [B] [f( )=], expression f(AB) = is entered and store memories A and B are designated as variables.

[2ndF] [VAR] : Variable Character Input Mode Key
AER Mode:
Used to set the VAR mode when you wish to enter any of characters for variables for programming. The VAR indicator appears in the display while the calculator is in the VAR mode.

$\boxed{\alpha}$: Alpha key
VAR mode:
Used to enter Greek letter "α" as a variable.

$\boxed{\beta}$: Beta Key
VAR mode:
Used to enter Greek letter "β" as a variable.

$\boxed{\gamma}$: Gamma Key
VAR mode:
Used to enter Greek letter "γ" as a variable.

$\boxed{\theta}$: Theta Key
VAR mode:
Used to enter Greek letter "θ" as a variable.

Appendix B
Accuracy of Calculation

- Entries, and four basic arithmetic operation, 1st, 2nd operands, and calculation results:
  $\pm 1\times 10^{-99}$ to $\pm 9.999999999\times 10^{99}$ and 0

  NOTE:
  When the absolute value of a numeric entry or the result of a calculation is less than 1×10^{-99}, this calculator regards the value as 0 (zero) for calculation or display.

- Scientific and special functions:

Functions	Dynamic range
SIN x COS x TAN x	DEG: $\vert x\vert < 1\times 10^{10}$ RAD: $\vert x\vert < \frac{\pi}{180}\times 10^{10}$ GRAD: $\vert x\vert < \frac{10}{9}\times 10^{10}$ With TAN X, however, an error occurs in the following cases: DEG: $\vert x\vert = 90(2n-1)$ RAD: $\vert x\vert = \frac{\pi}{2}(2n-1)$ GRAD: $\vert x\vert = 100(2n-1)$ (n= integer)
SIN^{-1} x COS^{-1} x	$-1\leqq x\leqq 1$
TAN^{-1} x	$\vert x\vert < 1\times 10^{100}$
LN x LOG x	$1\times 10^{-99}\leqq x < 1\times 10^{100}$
e^x	$-1\times 10^{100} < x < 230.2585093$
10^x	$-1\times 10^{100} < x < 100$

Functions	Dynamic range
y^x	• $y>0$ $-1\times10^{100} < x\ \mathrm{LOG}y < 100$ • $y=0$ $0<x<1\times10^{100}$ • $y<0$ $-1\times10^{100}<x\ \mathrm{LOG}\mid y\mid<100$ where x : integer or $\frac{1}{x}$: odd number$(x\neq0)$
$\sqrt[x]{y}$	• $y>0$ $-1\times10^{100}<\frac{1}{x}\mathrm{LOG}\ y<100 \quad (x\neq0)$ • $y=0$ $0<x<1\times10^{100}$ • $y<0$ $-1\times10^{100}<\frac{1}{x}\mathrm{LOG}\mid y\mid<100$ where x : odd number or $\frac{1}{x}$: integer$(x\neq0)$
$\sqrt[3]{x}$	$\mid x\mid<1\times10^{100}$
SINH x COSH x TANH x	$-227.9559243<x<230.2585093$
$\mathrm{SINH}^{-1}x$	$\mid x\mid<1\times10^{50}$
$\mathrm{COSH}^{-1}x$	$1\leqq x<1\times10^{50}$
$\mathrm{TANH}^{-1}x$	$\mid x\mid<1$
$\sqrt{x}$	$0\leqq x<1\times10^{100}$
x^2	$\mid x\mid<1\times10^{50}$
x^{-1}	$\mid x\mid<1\times10^{100} \quad (x\neq0)$
n!	$0\leqq n\leqq69$ (n : integer)
xCy xPy	$0\leqq y\leqq x\leqq69$ (x,y : integer)
→POL	$\mid x\mid<1\times10^{50}$, $\mid y\mid<1\times10^{50}$ $x^2+y^2<1\times10^{100}$ $\mid\frac{y}{x}\mid<1\times10^{100}$
→REC	$0\leqq r<1\times10^{100}$ Same range as trigonometric functions apply to the angle

Functions	Dynamic range
→DEG →D.MS	$\mid x \mid < 1 \times 10^{100}$
Conversions →DEC →BIN →OCT →HEX	Converted result: DEC: $\mid x \mid \leqq 9999999999$ BIN: $\bullet\ \underbrace{1000000000000000}_{16\ \text{digits}} \leqq x \leqq 1111111111111111$ $\bullet\ 0 \leqq x \leqq 0111111111111111$ OCT: $\bullet\ 4000000000 \leqq x \leqq 7777777777$ $\bullet\ 0 \leqq x \leqq 3777777777$ HEX: $\bullet$ FDABF41C01 $\leqq x \leqq$ FFFFFFFFFF $\bullet\ 0 \leqq x \leqq$ 2540BE3FF
Binary/octal/ hexadecimal number calculations NOT	BIN: $\bullet\ 1000000000000000$ $\leqq x \leqq 1111111111111111$ $\bullet\ 0 \leqq x \leqq 0111111111111111$ OCT: $\bullet\ 4000000000$ $\leqq x \leqq 7777777777$ $\bullet\ 0 \leqq x \leqq 3777777777$ HEX: $\bullet$ FDABF41C01 $\leqq x \leqq$ FFFFFFFFFF $\bullet\ 0 \leqq x \leqq$ 2540BE3FE
NEG	BIN: $\bullet\ 1000000000000001$ $\leqq x \leqq 1111111111111111$ $\bullet\ 0 \leqq x \leqq 0111111111111111$ OCT: $\bullet\ 4000000001$ $\leqq x \leqq 7777777777$ $\bullet\ 0 \leqq x \leqq 3777777777$ HEX: $\bullet$ FDABF41C01 $\leqq x \leqq$ FFFFFFFFFF $\bullet\ 0 \leqq x \leqq$ 2540BE3FF
Other binary/octal hexadecimal number calculations	The ranges for entries and calculation results in each mode are the same as the above conversions

Functions		Dynamic range
Statistical calculation	DATA CD	$\lvert x \rvert < 1\times10^{50}$ $\lvert y \rvert < 1\times10^{50}$ $\lvert \Sigma x \rvert < 1\times10^{100}$ $\Sigma x^2 < 1\times10^{100}$ $\lvert \Sigma y \rvert < 1\times10^{100}$ $\Sigma y^2 < 1\times10^{100}$ $\lvert \Sigma xy \rvert < 1\times10^{100}$ $\lvert n \rvert < 1\times10^{100}$
	$\bar{x}$	$n \neq 0$
	sx	$n \neq 0,1$ $\lvert \Sigma x \rvert < 1\times10^{50}$ $0 \leq \frac{\Sigma x^2-(\Sigma x)^2/n}{n-1} < 1\times10^{100}$
	σx	$n \neq 0$ $\lvert \Sigma x \rvert < 1\times10^{50}$ $0 \leq \frac{\Sigma x^2-(\Sigma x)^2/n}{n} < 1\times10^{100}$
	$\bar{y}$ sy σy	Same as $\bar{x}$, sx, σx
	r	$n \neq 0$ $\lvert \Sigma x \rvert < 1\times10^{50}$ $\lvert \Sigma y \rvert < 1\times10^{50}$ $0 < (\Sigma x^2-\frac{(\Sigma x)^2}{n})(\Sigma y^2-\frac{(\Sigma y)^2}{n}) < 1\times10^{100}$ $\lvert \Sigma xy-\frac{\Sigma x\Sigma y}{n} \rvert < 1\times10^{100}$ $\left\lvert \frac{\Sigma xy-\frac{\Sigma x\Sigma y}{n}}{\sqrt{(\Sigma x^2-\frac{(\Sigma x)^2}{n})(\Sigma y^2-\frac{(\Sigma y)^2}{n})}} \right\rvert < 1\times10^{100}$
	b	$n \neq 0$ $\lvert \Sigma x \rvert < 1\times10^{50}$ $\lvert (\Sigma x)(\Sigma y) \rvert < 1\times10^{100}$ $0 < \lvert \Sigma x^2-\frac{(\Sigma x)^2}{n} \rvert < 1\times10^{100}$ $\lvert \Sigma xy-\frac{\Sigma x\Sigma y}{n} \rvert < 1\times10^{100}$ $\left\lvert \frac{\Sigma xy-\frac{\Sigma x\Sigma y}{n}}{\Sigma x^2-\frac{(\Sigma x)^2}{n}} \right\rvert < 1\times10^{100}$

Functions		Dynamic range
Statistical calculation	a	Same as b, except the following: $\mid b\bar{x} \mid < 1 \times 10^{100}$ $\mid \bar{y} - b\bar{x} \mid < 1 \times 10^{100}$
	y′	$\mid bx \mid < 1 \times 10^{100}$ $\mid a + bx \mid < 1 \times 10^{100}$
	x′	$\mid y - a \mid < 1 \times 10^{100}$ $\left\lvert \frac{y-a}{b} \right\rvert < 1 \times 10^{100}$

NOTE:
In the above calculation range, the calculation results or intermediate results are treated or displayed as 0 (zero) when their absolute values are less than 1×10^{-99}.

- As a rule, the error of functional calculations is less than ± 1 at the lowest digit of a displayed numerical value (at the lowest digit of mantissa in the case of scientific notation system) within the above calculation range. In the calculation of SINH x and TANH x, x is a singular point when it is 0 (zero). Near this point the error is accumulated, reducing the accuracy.

Appendix C
How to Check Remaining Bytes

How To Check Remaining Bytes

To confirm the number of bytes (for example, 1427 bytes) remaining in memory, press the [2ndF] and [M.CK] keys. Keep pressing the [M.CK] key following [2ndF], and the display will show the number of bytes left in the memory as follows.

```
1427  BYTES  LEFT
```

When you store a number of programs (algebraic expressions) in memory, write a program into memory while confirming the remaining bytes from time to time through this operation. Bytes are the number of bits that a computer or programmable calculator processes as a unit. With the EL-5150, one byte corresponds to one program step.

How To Count Number of Program Steps

A program titled "PYTHAGORAS" and stored in memory in the programming example on page 69 is used here as an example of counting the number of steps.

- Title

1	2	3	4	5	6	7	8	9	10	11	12	13
Ø1	:	P	Y	T	H	A	G	O	R	A	S	

14. . . . 160 ← Number of steps

(ENT)

Because a title is stored in memory as shown in the above example, a memory space of 14 steps is required in this case. The total number of steps for a title consists of the number of title characters plus 4 steps.

• Main routine and subroutine

1	2	3	4	5	6	7	8	9	10	11	12	13
M:	f(	A	B	)=	$\sqrt{\ }$	(	A	x^2	+	B	x^2	)

14 .... 160 ← Number of steps

ENT

The total number of steps for entry of a main routine or subroutine consists of the number of steps entered plus 2 steps.

NOTE:

1. ENT and SUB keys are not included in the 160 steps permitted for a program entry, but these key entries require one byte of memory.
2. If variable characters are used for an algebraic expression, the calculator counts the total number of steps by adding the number of characters used as variables and 11 steps per variable to the number of steps entered.
3. If message "ERROR 4" appears in the display while writing an algebraic expression in memory, press the ON/C key to clear the error condition. Press the 2ndF and M.CK keys to check the remaining bytes and then either delete the excessive portion of the program contents previously stored in memory or enter the contents of the expression being programmed so as not to exeed the remaining bytes.

Appendix D
Error Conditions & Messages

Error Conditions

If you attempt to execute an operation exceeding the calculation range of the calculator or any illegal operation, the unit will detect such operation as an error condition and indicate the pertinent error code or message, prohibiting you from subsequent operations. To clear the error condition, press the [ON/C] key (or the [PB] key).

- If an error occurs, press the [PB] key and the location of the error will be indicated by a blinking cursor.

1 [÷] 0 [+] 5 [=]

ERROR 2

[PB]

1 ÷ Ø + 5 =

Error Messages

Code		Description of Error
ERROR 1	–	Syntax error (e.g., 3 [×] [+] 2)
ERROR 2	–	Calculation error: ● Result of an operation or the value of a pending operation exceeds the calculation range of the calculator. (See APPENDIX B for the calculation range.) ● Division by zero was attempted. ● Numeric entry exceeds the input range of the function in a scientific calculation. ● Statistical data for single-variable operation coexists with that for two-variable operation in the STAT mode.

- Illegal operation was attempted (e.g. $\sqrt{-1}$) or a scientific calculation was attempted in the BIN, OCT, or HEX mode.

ERROR 3 – Nesting error:

- Data or function exceeds the capacity of 8-stage data buffers or 16-stage function buffers.
- More than 15 loops are used in the looping feature.
- Attempt was made to jump from one subroutine to another.
- Attempt was made to display the calculation result of an expression more than 1,000 times.

ERROR 4 – Memory error/overflow:

- Program (or expression) exceeds the memory capacity.
- An error related to memory exists.

- If an error is found in a program (or expression) stored in the AER mode and executed with the [COMP] key in the COMP mode, main("M:") or subroutine (e.g. "1") indicator where the error has occurred will appear in the display, followed by the pertinent error code.

Example:

```
M: ERROR 1
```

Indicates that the error exists in a main routine.

To review the erroneous program line, press the [PB] key. The program line with a blinking cursor showing the location of the error will appear in the display when you keep pressing the [PB] key.

Appendix E
Priority Levels In Calculation & Pending Operations

Priority Levels

The EL-5150 is provided with a function that judges the priority levels of individual calculations. Normally, the unit permits you to perform the key operation of a given algebraic formula as written. The following shows the priority levels of individual calculations.

(1) (−)

(2) π, recall of memory contents, recall of answer memory

(3) Single-term function preceded by a number (Example: x^2, x^{-1}, n!, →DEG, →D.MS)

(4) Two-term function preceded and followed by a number (Example: nCr, nPr, Y^x, $^x\sqrt{\ }$, →POL, →REC)

(5) Multiplication where "×" command located just before a store memory or before a single-term function followed by a number has been omitted from entry. (Example: 2π, 4A)

(6) Single-term function followed by a number (Example: $\sqrt{\ }$, e^x, 10^x, $^3\sqrt{\ }$, LN, LOG, SIN, COS, TAN, SIN^{-1}, COS^{-1}, TAN^{-1}, SINH, COSH, TANH, $SINH^{-1}$, $COSH^{-1}$, $TANH^{-1}$, ABS, INT, FRAC, NEG, NOT)

(7) ×, ÷

(8) +, −

(9) AND

(10) OR, XOR, XNOR

(11) =, M+, M− (2ndF M+), ⇒M, STO A ~ STO Z, →BIN, →OCT, →HEX, →DEC, ␣ (space), , (comma), DATA, CD, (x,y), x',y', >, >=, ≠, ↳, ↰, −Y→[], −N→[], ►, etc.

- Parenthesized calculations have precedence to any other calculations.
- Provided that functions shown in item (6) above are successively designated in an algebraic expression, calculations are performed from the right to the left.

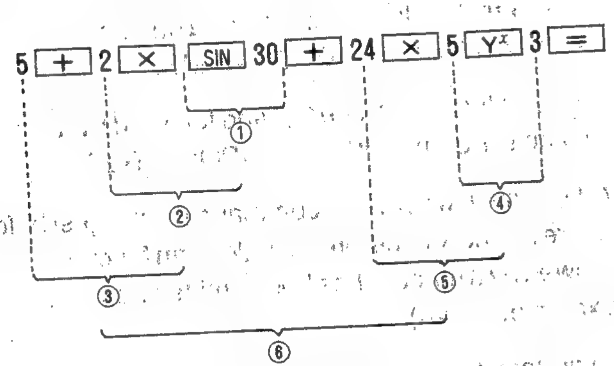
  Ex. $e^x \text{LN} \sqrt{}\ 120 \rightarrow e^x\{\text{LN}(\sqrt{}\ 120)\}$

- The other functions are calculated from the left to the right.

  Ex. $A\ {}^x\!\sqrt{}\ BY^xCY^xD \rightarrow \{(A\ {}^x\!\sqrt{}\ B)Y^xC\}Y^xD$

Order of calculations in a typical example:

Ex. $5+2\times\text{SIN}\,30+24\times5^3=$



Pending Operations

When the calculator performs calculations according to the established priority levels or performs a parenthesized calculation before any other calculations, the unit must suspend or set aside the calculation commands and numbers (or values) that cannot be processed immediately. For this reason, the calculator is provided with a memory area for pending operations, consisting of a 16-stage function buffer and a 8-stage data buffer. In other words, a maximum of 16 calculation commands and a maximum of 8 numbers can be stored in the memory area. Note that an error condition occurs if this memory capacity is exceeded by these pending operations.

Example 1

Calculation with 8 pending numbers

$1 + 2 \times (3 - 4 \div (7 \div 5 \sqrt[x]{\ } (7 \times 6Y^x 3 =$

① ② ③ ④ ⑤ ⑥ ⑦ ⑧

$14 - 5 + 4 \times SIN2AY^x (2 + 3 \div LOG3B \sqrt[x]{\ } 48 =$

① ② ③④ ⑤ ⑥ ⑦⑧

When the calculator reaches the next Add "+" command, it executes 14−5 and holds the calculation result of 9 in the data buffer.

Store memory such as A or B is regarded as a number and is temporarily held in the data buffer.

Example 2:

Calculation with 16 calculation commands including parentheses

$((2+12\div 4\times 3Y^x((((3+2-4\sqrt{\ }LOG\sqrt[3]{\ }4A^2$

①② ③ ④ ⑤ ⑥~⑨ ⑩ ⑪ ⑫ ⑬ ⑭ ⑮⑯

When the calculator reaches "×" Command, it executes division 12 ÷ 4, with the result of 3 ×.

When the calculator reaches the "−" command, it executes addition 3+2, with the result of 5−.

"×" command was omitted from entry ($4\times\sqrt{\ }$, $4\times A^2$) but the calculator assumes the presence of the "×" command when executing the multiplication.

Appendix F
Battery Replacement

The EL-5150 uses two lithium batteries as its main DC power supply. The calculator also uses another lithium battery for memory backup.

- When replacing either of the two types of batteries, be sure to set the Model Selector switch of the calculator to the OFF position.
- Do not replace the batteries for main DC power and memory backup at the same time, or the memory contents of the calculator may be lost.

When to Replace Batteries for Main DC Power Supply
The Contrast knob is located on the right side of the calculator as viewed from its front. Turn the knob counterclockwise for a higher contrast. If the indicators and numbers in the display (LCD) appear to be dim, it is the signs of the low battery voltage, meaning that the batteries are nearing the end of their life. Replace the batteries as quickly as possible. Note that use of the calculator with the exhausted batteries may result in loss of the memory contents.

How to Replace Batteries for Main DC Power Supply
(1) Slide the Mode Selector switch to the OFF position to turn off the power.

(2) Remove the two set screws with a phillips screwdriver from the rear of the calculator and detach the rear cover.

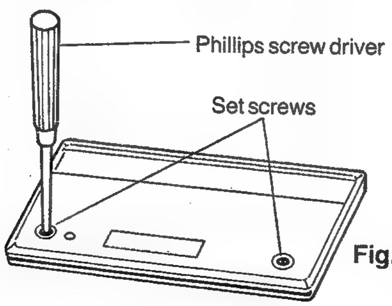


Fig. 1

(3) Slide the Battery ON/OFF switch to the OFF position.

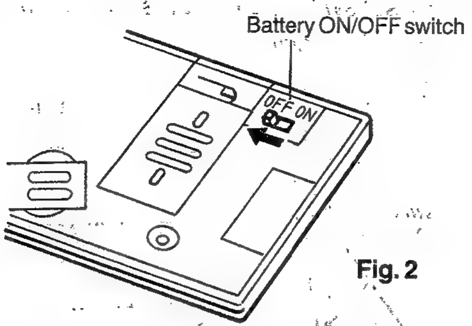


Fig. 2

(4) Push the stopper to slide the battery keep plate in the direction of the arrow and remove the keep plate.

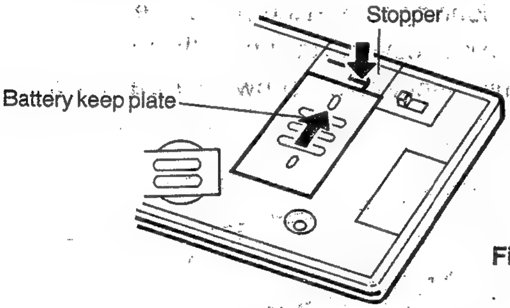


Fig. 3

(5) Remove the two old batteries from the battery compartment and replace them with two new ones (CR-2032 lithium batteries) with attention paid to the polarity as shown in Fig. 4. Before inserting the two new batteries, wipe them clean with a dry cloth. When replacing the main DC power supply, do not unload the memory backup battery.

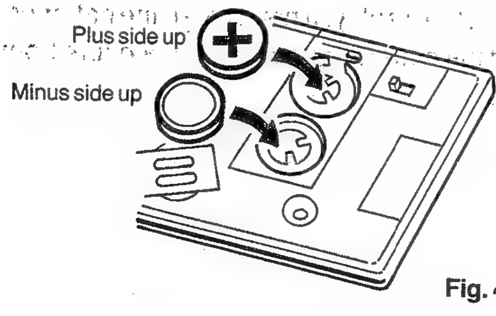


Fig. 4

(6) Put the battery keep plate back to its original position, push the Reset switch, and then slide the battery ON/OFF switch to the ON position.

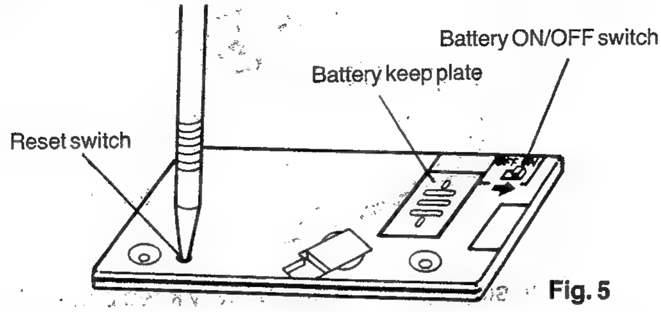


Fig. 5

(7) Hooks the four claws (or projections) of the rear cover into the corresponding slots at the side of the calculator and secure the rear cover to the unit with the two setscrews while gently holding down the rear cover.

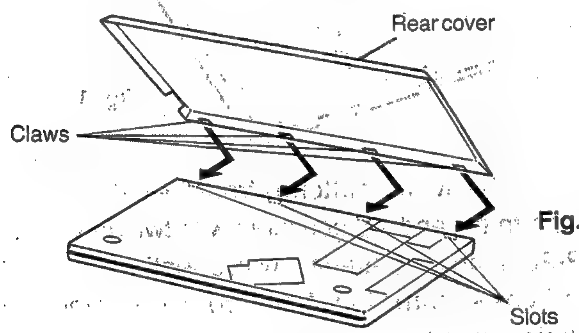
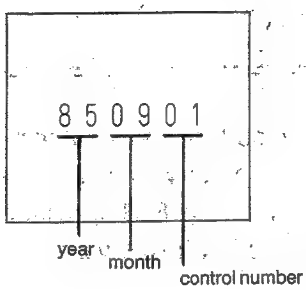


Fig. 6

(8) Slide the Mode Selector Switch to the COMP position and push the Reset switch again to confirm that "Ø." is appearing in the display. If not, unload the batteries and repeat the battery replacement procedure from the beginning.

Life of Memory Backup Battery

The memory backup battery will protect the calculator's memory contents for about 5 years at a room temperature of 20°C. The date (year and month) of battery loading is indicated on the label attached to the rear of the calculator at the time of its shipment. Refer to this date for determining the appropriate time of battery replacement.



NOTE:

The service life of the battery is governed by its operating environments and may be shortened from use at extremely high or low temperatures. In the worst case, this may result in loss of data or destruction of the memory contents.

How to Replace Memory Backup Battery

Before replacing the backup battery, make sure that the batteries for the main DC power supply have not become exhausted. If exhausted, replace the main batteries first and then the backup battery, or the memory contents of the calculator may be lost.

(1) Slide the Mode Selector switch to the OFF position.

(2) Remove the two setscrews from the rear of the calculator and detach the rear cover as shown in Fig. 1.

(3) Unscrew the battery keep plate with a phillips screwdriver and remove it.

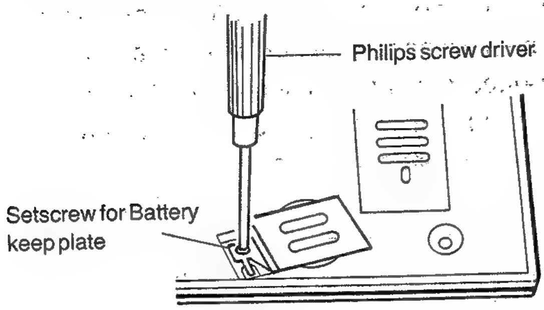


Fig. 7

(4) Remove the old battery and replace it with a new one (CR-2032 lithium battery) with attention paid to the polarity as shown in Fig. 8. Before inserting the new battery, wipe it clean with a dry cloth.

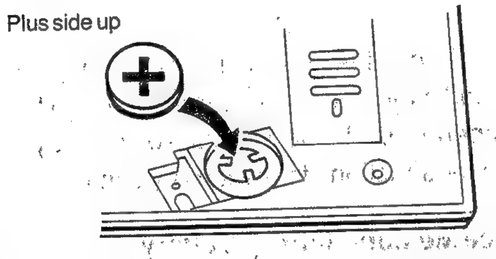


Fig. 8

(5) Secure the battery keep plate with the setscrew.

(6) Secure the rear cover to the unit as shown in Fig. 6.

Hints on Use of Batteries

1. When replacing the two main batteries, be sure to replace both batteries at the same time.
2. Avoid replacing the main batteries with one fresh and one used batteries combined.
3. Use the lithium batteries of the same type for replacement.
4. Insert the replacement batteries with attention paid to the polarity as indicated in the battery compartment (i.e., plus side up and minus side up).

5. Replace the memory backup battery every 5 years.

Cautions

- Keep the batteries out of reach of children.
- Dispose of old batteries safely. The batteries may explode if placed in a fire.
- The original batteries were installed upon shipment from the factory, so the battery life may be somewhat less than the normal 420 hours operating time.
- Remove the batteries when they become exhausted or if they are to be stored indefinitely. The batteries may leak and cause damage.

Date of Battery Replacement Label

A label is attached to the inside of the plastic cover to enter the date of battery replacement. Be sure to enter the initial date of replacement so that it may be used as a guide in determining the appropriate time of subsequent replacement.

Appendix G
Specifications

Model:	EL-5150
Number of internal calculation digits:	Mantissa: 12 digits; Exponent: 2 digits
Calculation system:	As per algebraic expression (with priority judging function)
Memory:	26 memories A-Z (one independent accessible memory or store memory and 25 store memories)
Display type:	Dot matrix liquid crystal display (24 digits, 5x7 dots)
Display capacity/mode:	Mantissa: 10 digits; Exponents: 2 digits Automatic changeover between the floating decimal point display system and any of the following display systems: Fixed decimal point system (FIX) Scientific notation (SCI) Engineering notation (ENG)
Calculations:	Four basic arithmetic operations, trigonometric and inverse trigonometric functions, hyperbolic and inverse hyperbolic functions, conversion of angles, reciprocals, square root and cubic root, square and power, logarithmic and exponential functions, Xth

	root of Y ($\sqrt[x]{y}$), factorial, permutations, combinations, conversions of coordinates, memory calculations, statistical calculations, binary/octal/hexadecimal number calculations, logical operations, absolute value, integer/fraction part, modify, answer memory, etc.
Memory check function:	Remaining bytes is displayed
AER functions:	Variable designation, expression separation, end of command, conditional judgement, looping, subroutine, title search, etc.
General calculation capacity:	160 steps
Algebraic expression reserve capacity:	1454 steps
Display control function:	Cursor step-up, cursor step-down, insertion, deletion, and playback
Components:	LSI, etc.
Power supply:	6V⎓(DC) main: Lithium battery (CR2032)×2 3V⎓(DC) backup: Lithium battery (CR2032)×1
Power consumption:	0.015W
Operating time:	Approx. 420 hours continuous (at 20°C with 10-minute operation/hour, 50-minute display)

Memory backup:	Approx. 5 years
Operating temperature:	0° to 40°C (32° to 104°F)
Dimensions:	170(W)×72(D)×9.5(H) mm
Weight:	130g (including batteries)
Accessories:	Plastic cover, 3 built-in lithium batteries and Operation Manual